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AVERAGE MONTHLY WIND STRESS ALONG COASTAL REGIONS OF THE U.S. A--ETC(U)
1977 C W MORGAN , W H ANTHONY

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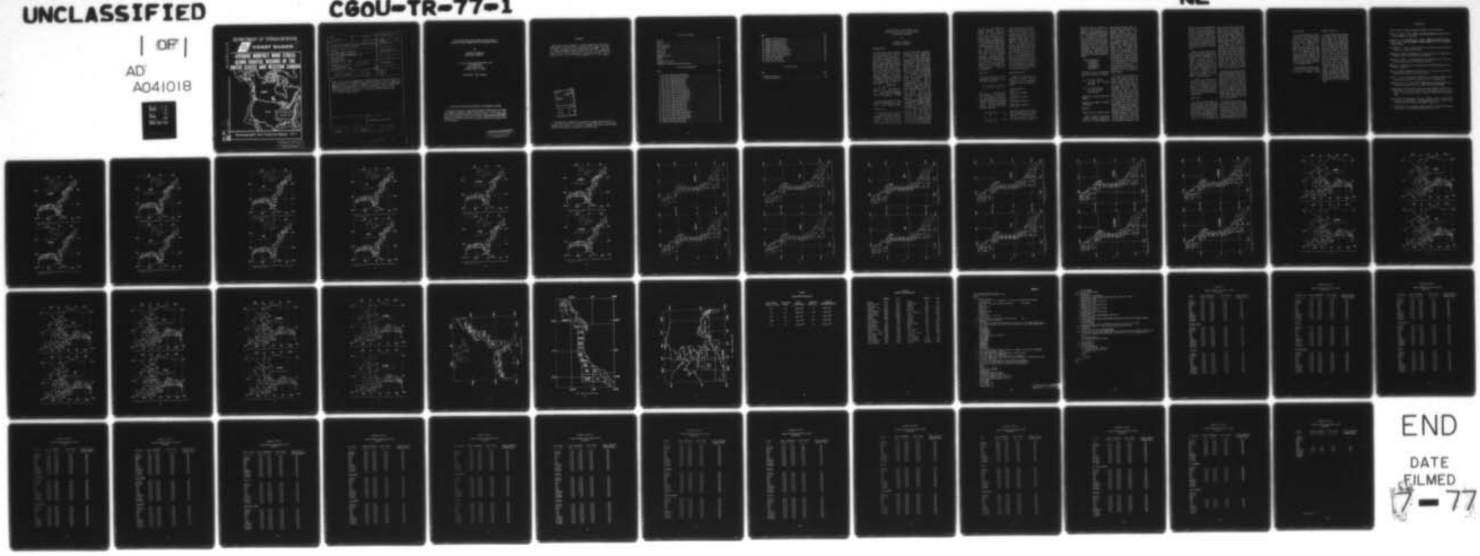

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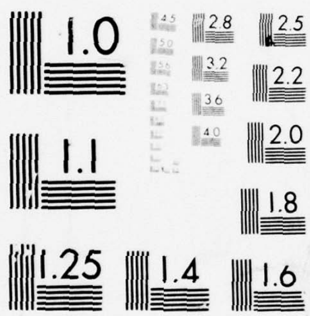

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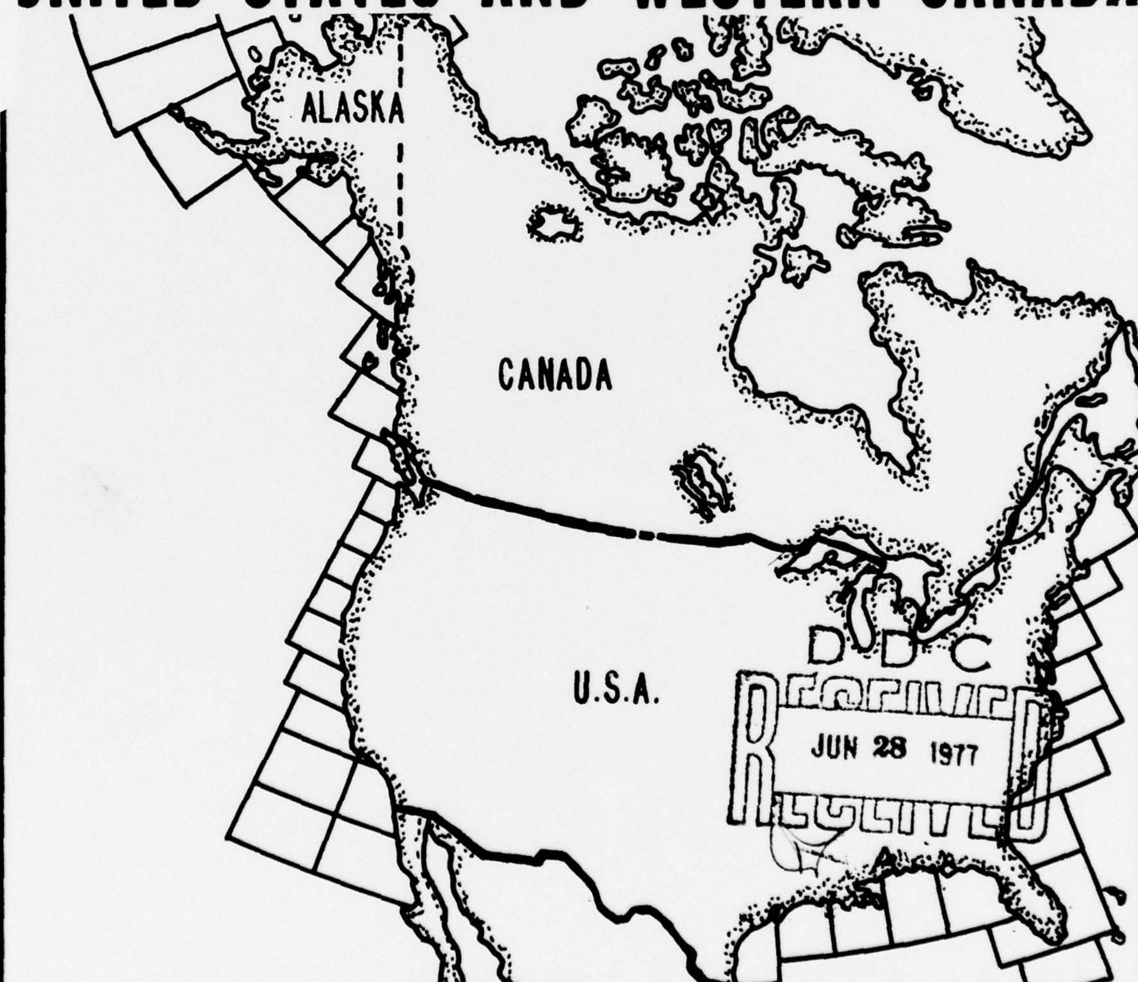
AVERAGE MONTHLY WIND STRESS ALONG COASTAL REGIONS OF THE UNITED STATES AND WESTERN CANADA



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16. Abstract

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AVERAGE MONTHLY WIND STRESS ALONG COASTAL REGIONS OF THE UNITED STATES AND WESTERN CANADA

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ABSTRACT

Values of the X and Y components of average monthly surface wind stress for coastal regions of the United States are presented on a series of charts. Sea surface wind stress, $\vec{\tau}$, was computed for a formula of the form $\vec{\tau} = \rho_a C_d \vec{W}|\vec{W}|$ using a value ρ_a (density) of (0.0022 x Latitude + 1.136) x 10^{-3} g cm^{-3}, C_d (drag coefficient) of 0.85 x 10^{-3} for $0 \leq W$ (wind speed) $\leq$ 6 knots, 1.09 x 10^{-3} for $7 \leq W \leq 16$ knots, 2.2 x 10^{-3} for $17 \leq W \leq 27$ knots, and 2.43 x 10^{-3} for $W \geq 28$ knots.

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AVERAGE MONTHLY WIND STRESS ALONG COASTAL REGIONS OF THE UNITED STATES AND WESTERN CANADA

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INTRODUCTION

In the course of work on modeling the average seasonal surface current in coastal regions of the United States a need arose for average wind stress data. Such data for the world's oceans are given by Scripps Institute of Oceanography (1948, 1950), Hidaka (1958) and Hellerman (1967, 1968); however the 5° data interval used by them is felt to be too gross for use in coastal work where local effects on a smaller scale are important. Using a simplification of the procedure described in Hellerman (1965) the wind stress was computed using a resistance law (Defant, 1961; p. 422):

$$\vec{\tau} = \rho_a C_d \vec{W} |\vec{W}|$$

with stress, $\vec{\tau}$ being equal to air density, ρ_a, times a drag coefficient, C_d multiplied by the wind velocity times the wind magnitude, $\vec{W}|\vec{W}|$.

The value of air density used in this study was (0.0022 x Latitude + 1.136) x 10^{-3} g cm^{-3} (Hellerman, 1965).

VALUE OF C_d

The value of the drag coefficient, C_d, has been the subject of many investigations. Most have found that C_d increased in some manner with increases in the easily measured parameter of wind speed (see, for example, Deacon and Webb, 1962). However investigators have also recognized that the problem is quite complex with C_d also depending on the relative roughness of the water surface (Rossby and Montgomery, 1935, referenced in Defant, 1961; p. 421) and on the stability of the air above the sea surface (see, for example, DeLeonibus, 1971). Recent work by SethuRaman and Raynor (1975) for winds of 3-10 m sec^{-1} found that C_d increased with increases in a roughness Reynolds number $U_* z_0 / \nu$ (where U_* is surface friction velocity, z_0 is roughness length, and ν is kinematic viscosity) for three distinct classes of aerodynamic roughness: smooth, moderately rough, and fully rough. They also concluded, contrary to many authors, that C_d did not vary with mean wind speed, at least in the range 3-10 m sec^{-1} (6-20 kn); they did find that C_d was weakly dependent on the atmospheric stability, in general decreasing with increasing stability. The question of which of the many formulations of C_d to use in this study was finally resolved in favor of one used in the earlier study by Hellerman (1967, 1968, Table 1). Hellerman's values of C_d were adopted from Deacon, Sheppard, and Webb (1956, referenced in Hellerman 1967). The values used are shown in Table 1. The values for winds speeds 7-16 kn

and 17-27 kn were obtained by averaging Hellerman's values for Beaufort force 3-4 and 5-6 respectively. A C_d of 2.43×10^{-3} was used for all winds greater than or equal to 28 kn. Use of these values permits comparison with Hellerman's work. It has the disadvantage of being at variance with the recent conclusions of SethuRaman and Raynor that C_d does not vary with mean wind speed. However, it may be that at wind speeds above the maximum 10 m sec^{-1} (20 kn) studies by SethuRaman and Raynor, there is a dependence of the roughness length, z_0, and thus C_d, on the mean wind speed. This would explain the findings of many investigators who have formulated C_d in terms of mean wind speed.

WIND DATA

The actual computation of the contribution to the wind stress from direction j was calculated as:

$$\tau_j = \sum_i \rho_a (C_d)_i f_{ij} W_i^2 \quad (1)$$

where $(C_d)_i$ is the drag coefficient appropriate to the speed interval i, f_{ij} is the percent frequency of the total wind distribution occurring within speed interval i from direction j, and W_i is the mean wind speed in interval i. The total wind stresses were then computed as:

$$\tau_x = \sum_j \tau_{xj} \quad (2)$$

$$\tau_y = \sum_j \tau_{yj} \quad (3)$$

Data for the wind speed distribution was taken from the Table 3A of the U.S. Naval Weather Service Command Series of Surface Synoptic Meterological Observations for North American Coastal Marine Areas (SSMO) (U.S. Naval Weather Service, 1970), for each month at each coastal area. The table has the wind distributed into eight directions with five wind speed intervals; 0-6, 7-16, 17-27, 28-40, and 41 + knots. The table lists the percentage frequency f_{ij}, of the eight directions N, NE, E, SE, S, SW, W, NW at the wind speed interval indicated. The mean wind speed in the interval was estimated as the average of the range of speeds for that interval, except for the 41 + interval, for which 41 knots was used as the mean wind speed.

PROGRAM TAUCOM

Computations for wind stress were carried out in program TAUCOM, (Appendix A). In the program, the wind speed squared was designated as follows.

UA(3 knots)=23777.6 $cm^2\ sec^{-2}$

UB(11.5 knots)=349399.2 $cm^2\ sec^{-2}$

UC(22 knots)=1278708.6 $cm^2\ sec^{-2}$

UD(34 knots)=3054105.8 $cm^2\ sec^{-2}$

UE(41 + knots)=4441134.8 $cm^2\ sec^{-2}$

and the drag coefficients were designated CA through CD with values from 0.85×10^{-3} through 2.43×10^{-3}. Each direction towards which the wind was blowing was assigned a

number; N=1, NE=2, E=3, SE=4, S=5, SW=6, W=7, NW=8. The term f_{ij} in equation (1) was represented by FA (K) for the wind intervals UA through UE. A wind stress was calculated for each wind direction so that T (1) = stress to the north, T(2) = stress to the northeast and so on. The surface of the coastal area was placed in a cartesian coordinate system with positive T_x representing a stress toward the east and positive T_y representing a stress toward the north. Thus the wind stress equation from any direction appears as follows:

```
T(K)=CA*FA(K)*UA +
     CB*FB(K)*UB +
     CC*FC(K)*UC +
     CD*FD(K)*UD +
     CD*FE(K)*UE
```

The final T_y and T_x for a particular month and coastal area was computed as:

$$T_y = YU = T(1) + .707\,T(2) - .707\,T(4) - T(5) - .707\,T(6) + .707\,T(8)$$

$$T_x = XU = .707\,T(2) + T(3) + .707\,T(4) - .707\,T(6) - T(7) - .707\,T(8)$$

Appendix A is a copy of the TAUCOM program.

Appendix B is a listing of TAUCOM stress outputs.

RESULTS

Atlantic and Gulf of Mexico Coasts

Figures 1 through 12 show average monthly wind stress as calculated by TAUCOM. The winter months December, January, February, along the east coast of the United States show a generally southeast stress. The magnitude of the stress generally decreases southward along the coast to the Charleston area. From Jacksonville to the Corpus Christi area the maximum magnitude appears in late fall. This difference is apparently due to the position of the North Atlantic High Pressure System. In December and January this high generally extends across the U.S. and mid-Atlantic area as a fairly wide (10°) belt. At the same time the Icelandic Low Pressure System lies generally over Eastern Greenland producing a moderate pressure gradient in the northeastern U.S. This would account for the 1.30 dynes cm^{-2} in the Boston and Quonset Point area. In the Charleston area the maximum is 0.88 dynes cm^{-2} , due to the lesser pressure gradient.

The areas from Jacksonville to Corpus Christi during January and February are influenced by the weak pressure gradient which occurs between the North Atlantic High Pressure System and the Inter-Tropical Convergence Zone (ITCZ). This is evident by the change in stress direction and the lower stress magnitudes. In March, from Boston to the Miami area the stress magnitudes begin to decrease appreciably due to the weakening pressure gradient between the Icelandic low and the North Atlantic high. The pressure gradient in the Gulf coastal area is generally weak. March also generally shows the first indication of the development of the thermal low pressure area of the Pacific southwest and Mexico. April shows the first significant change in stress direction along the east coast. This stress has shifted generally to the east-

northeast and decreased significantly in magnitude. The stress along the Gulf coast has shifted to the westnorthwest but has not changed significantly in magnitude. During the month of May the stress along the east coast is more to the northeast while along the Gulf coast the direction remains to the west-northwest but the gradient has increased producing an increase in the stress values.

During the summer months (June, July, August) the stress along the east coast has shifted predominately to the northeast and decreased to its minimum magnitude generally in August. However, July shows an increase in magnitude from June in all areas except Boston and the Gulf coast. The definite establishment of the southwest U.S. thermal low is the major factor producing the stress direction and magnitudes from the Miami to Corpus Christi areas.

In September the thermal low is beginning to dissipate and the direction of the stress along the east coast suggests a closed high pressure cell in the mid-U.S. This situation appears to remain through October and November. By November the thermal low is completely gone.

Pacific Coasts

The west coast areas (figures 13 through 36) from Eureka southward show the northern extent of the North Pacific High Pressure System during the winter months of December, January, and February. This high pressure area produces a definite southeasterly stress which is also evident throughout the entire year. The only change that occurs in these areas is in the magnitude of stress. The formation of the thermal low of the southwest U.S. produces a strong pressure gradient over these areas and reaches a maximum in May and June. During the winter months north of Eureka the areas of Seattle through Attu are influenced very strongly by the Aleutian Low Pressure System while the areas of North Bend to Astoria are a transitional zone. In the Gulf of Alaska and the Aleutian chain there are generally two centers of low pressure within the Aleutian Low System. This is evident from the stress vectors in the Sitka to Kodiak areas which show a definite cyclonic stress. The other local low pressure area is northwest of Unimak Island and is illustrated by the stress vectors in the areas around St. Paul.

During the spring months of March, April and May a ridge of high pressure begins to extend from the center of the North Pacific High in a northeasterly direction which is evident by the stress directions from Queen Charlotte to North Bend. At the same time the thermal low is forming in the southwest U.S., the magnitudes of the stress vectors show a significant increase from Eureka to Baja. The conditions in the Alaskan areas remain mostly the same as the winter conditions, except the lows are becoming weaker.

The summer months of June, July, and August generally produce the minimum in stress values in the Alaskan areas where the Aleutian Low System has degenerated into isolated local areas of weak low pressure. The areas from Seattle to San Diego are reaching a maximum magnitude with the pressure gradient being the greatest in the San

Francisco vicinity.

The fall months September, October, and November show the ridge of high pressure has retreated, the Aleutian Low has begun to deepen, and the thermal low of the southwest U.S. is weakening. The weakening of the thermal low also lessens the pressure gradient along the California coastal areas. The magnitude of the stress vectors in the areas of Seattle to San Diego generally reach a minimum. The magnitude of the stress vectors in the areas from Attu to Cordova and from Sitka to Vancouver show a marked increase during these months.

The areas from St. Lawrence to Barrow are not discussed due to the limited amount of monthly coverage.

Evaluation of Results

In interpreting and using this atlas, note should be taken of the source of the wind data. The Naval Weather Service SSMO s were compiled from punched cards of weather observations taken aboard ships of varying registry while in passage within the various areas shown in figures 37 through 39. Possible bias in this data could come from the tendency of ships to follow certain routes, or remain close to the coast, in some areas, thus making the data more representative of the specific route than of the area. An additional bias toward good weather samples would be introduced by the tendency of ships to avoid bad weather when possible. A final factor affecting the results is the number of samples in the month. An indication of the size of the samples is given in Table 2 which gives the number of observations reported in January and in July for the various areas.

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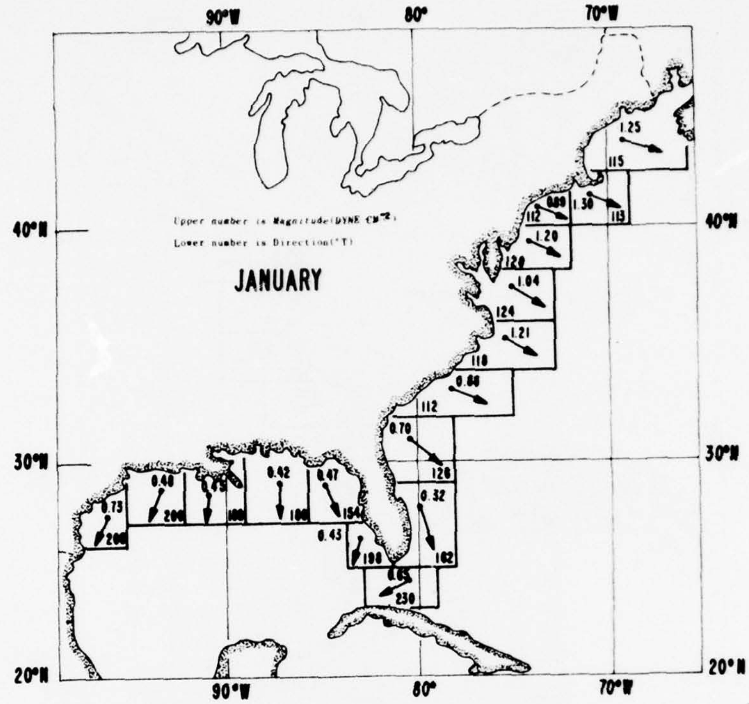
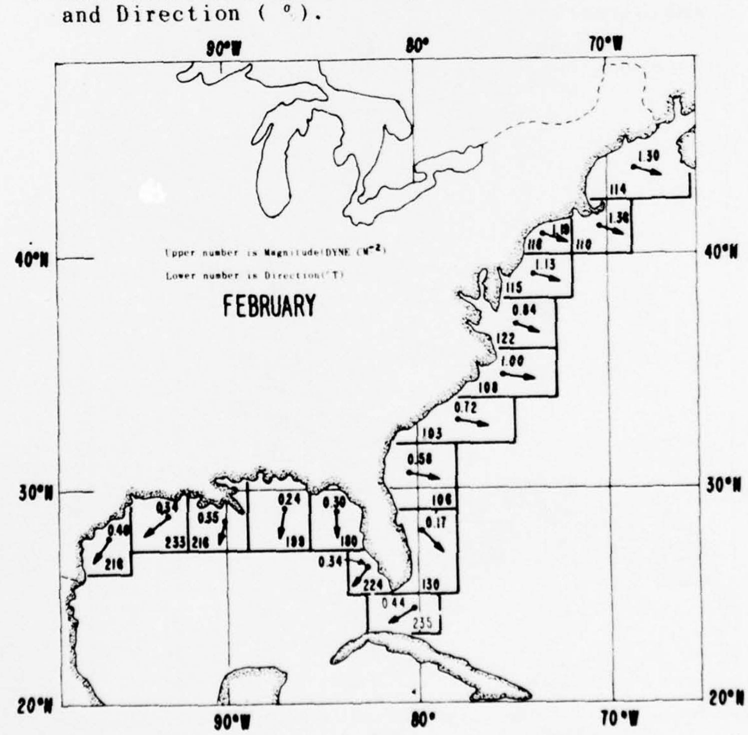


1. East Coast Average January wind Stress (dynes/cm^2) and Direction (°).



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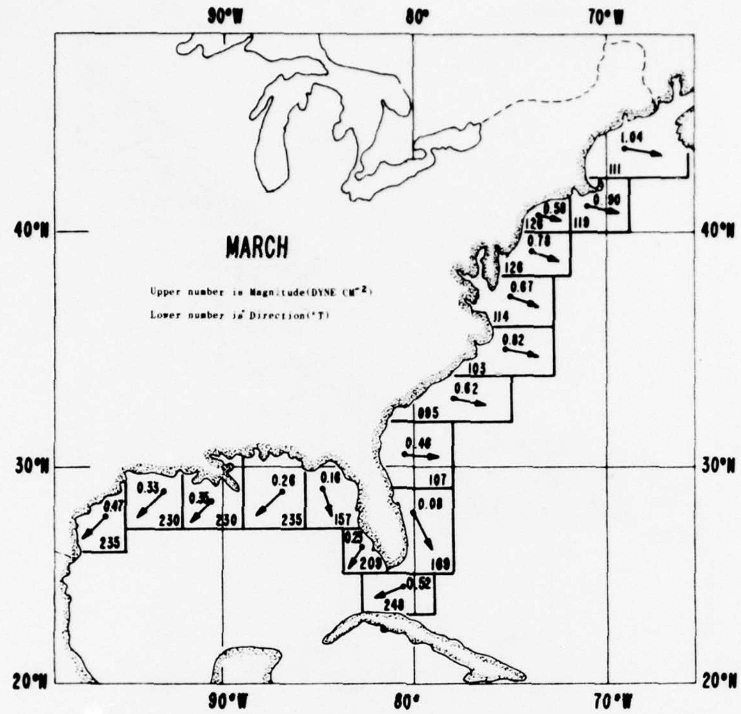
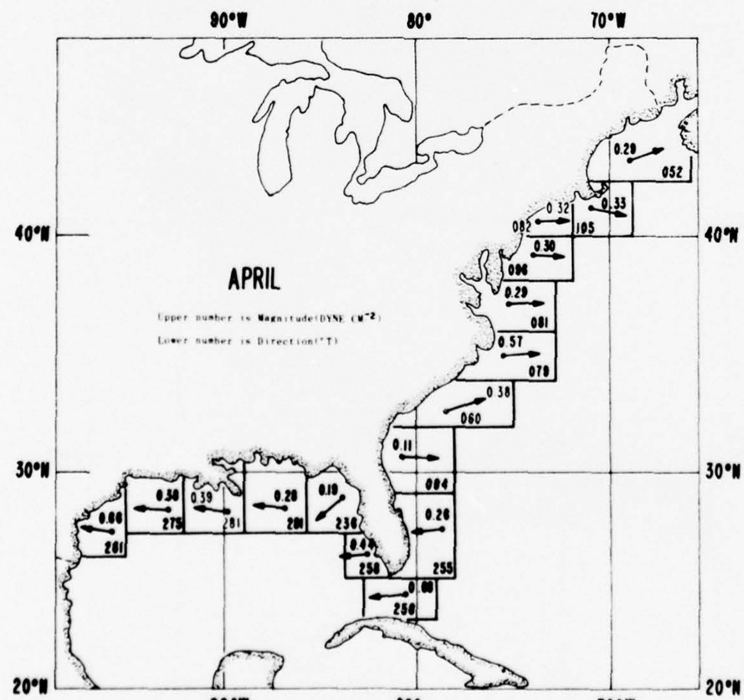
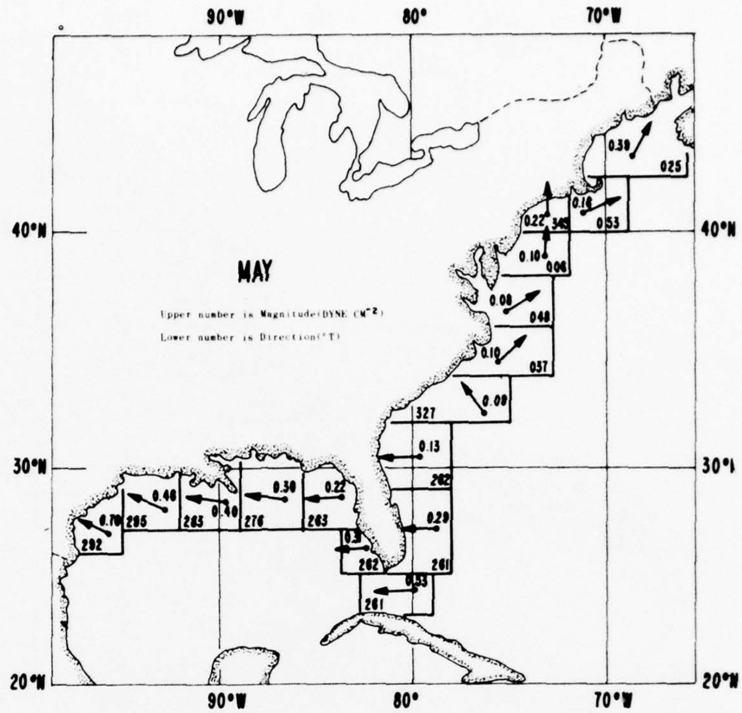


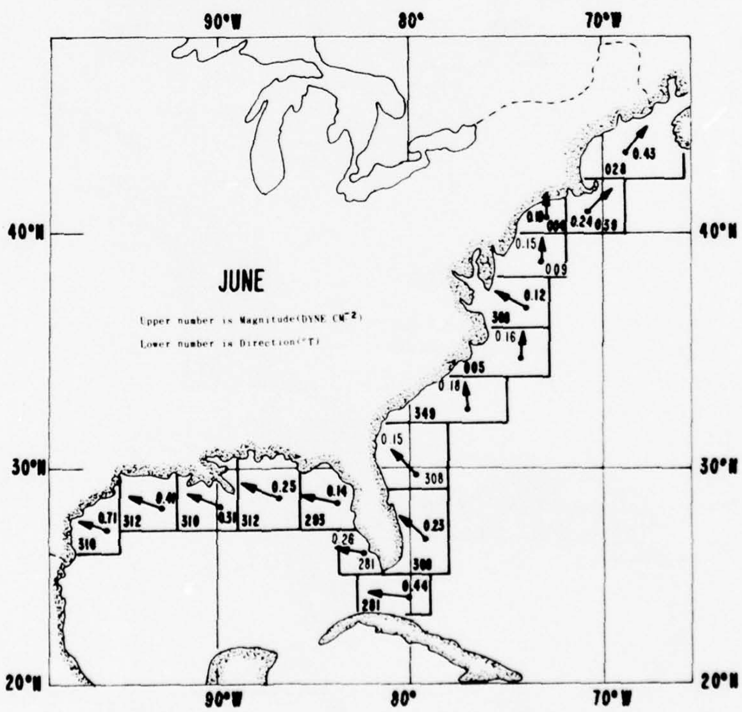
3. East Coast Coast March Wind Stress (dynes/cm^2) and Direction ($^{\circ}$).



4. East Coast Average April Wind Stress (dynes/cm^2) and Direction ($^{\circ}$).



5. East Coast Average May Wind Stress (dynes/cm^2) and Direction (^{o}).



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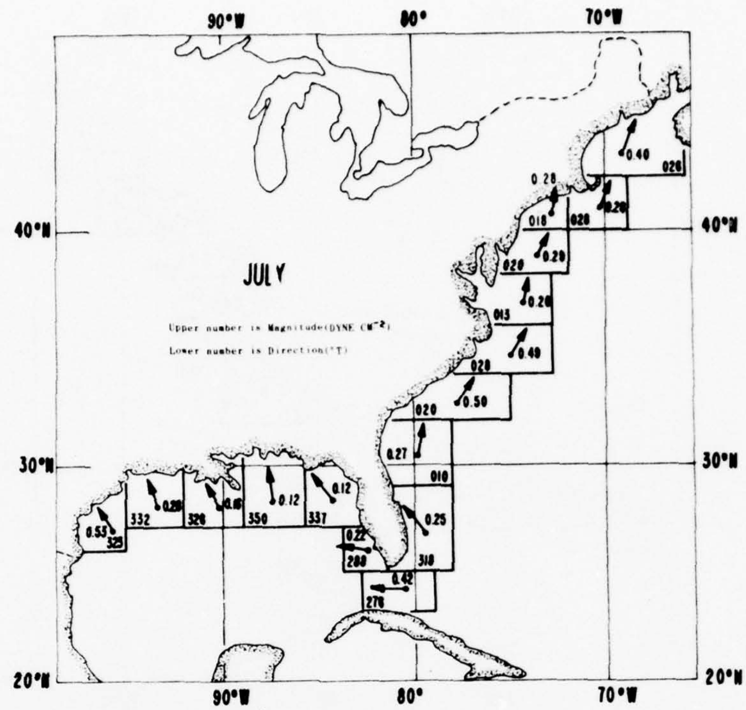
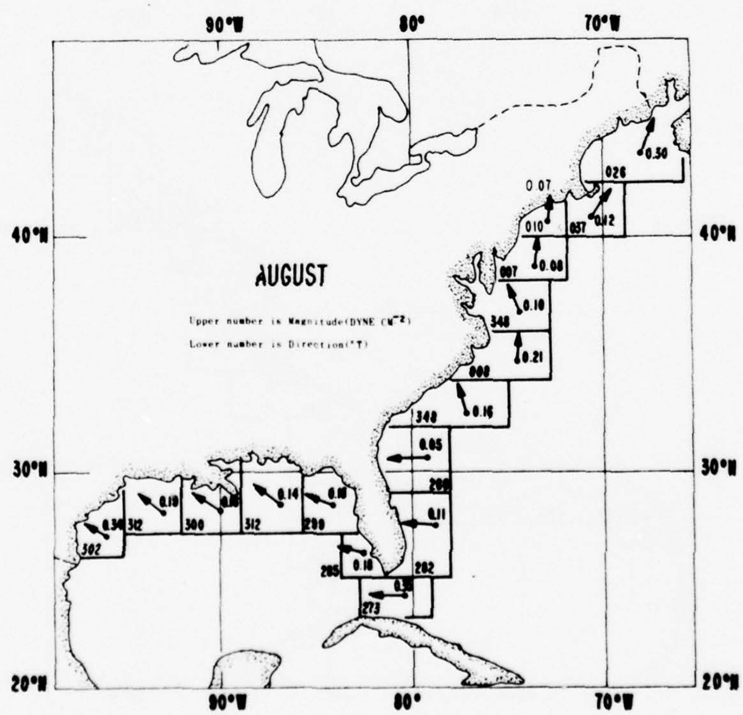


7. East Coast Average July Wind Stress (dynes/cm^2) and Direction (°).



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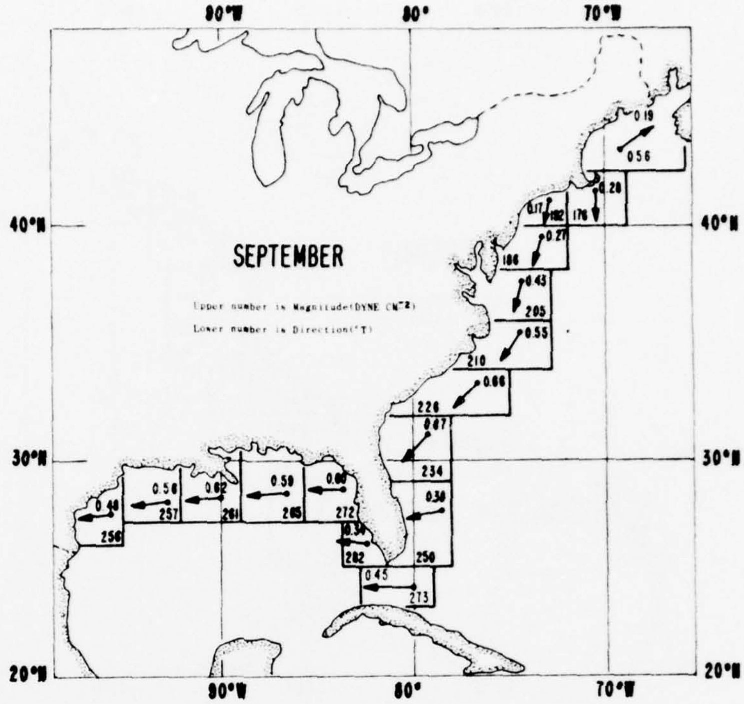
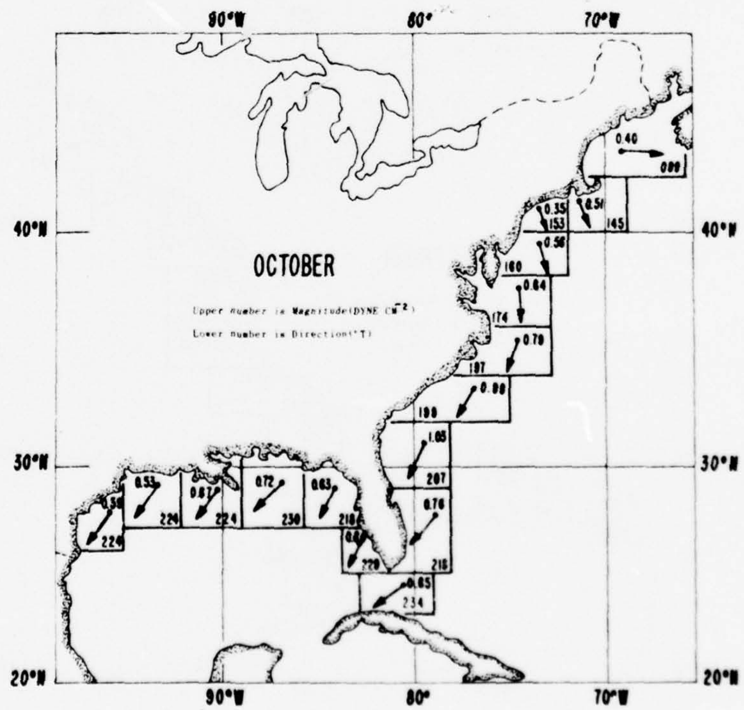


9. East Coast Average September Wind Stress (dynes/cm^2) and Direction (°).



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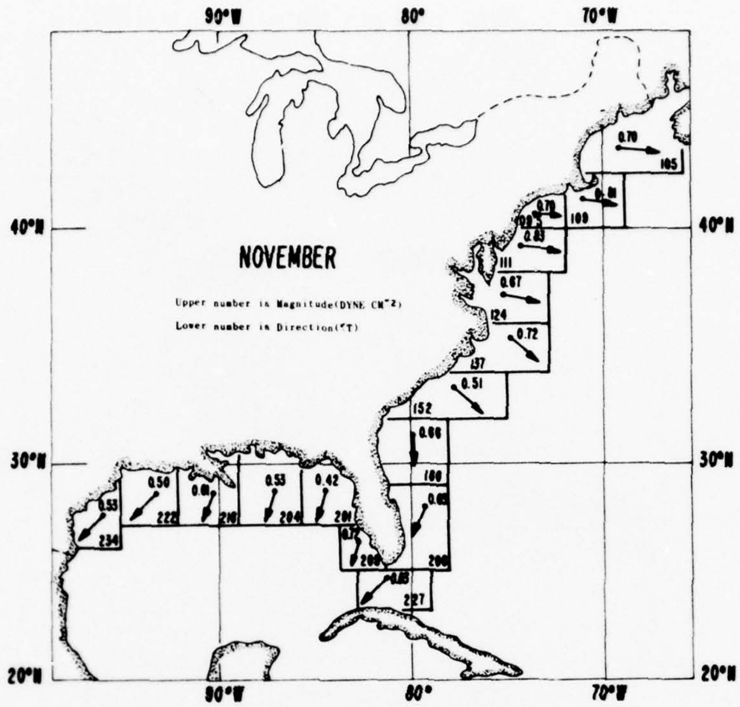
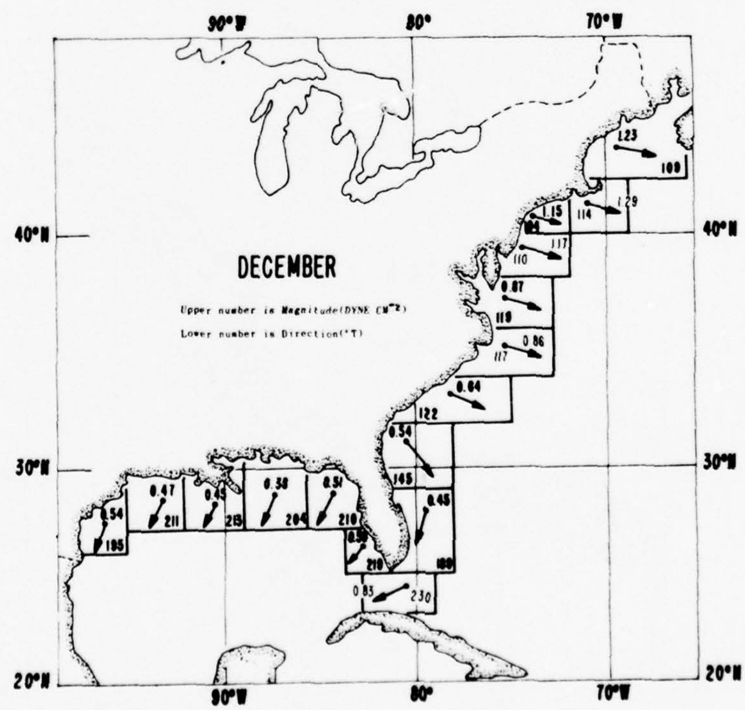


11. East Coast November Wind Stress (dynes/cm^2) and Direction (°).



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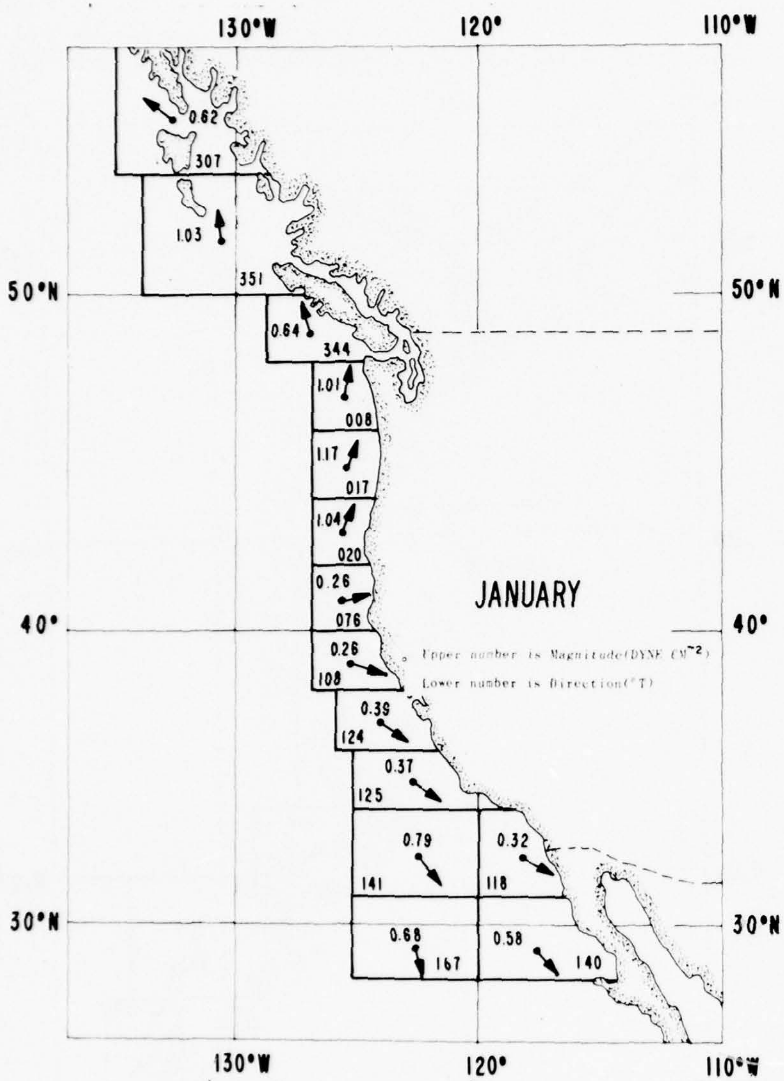
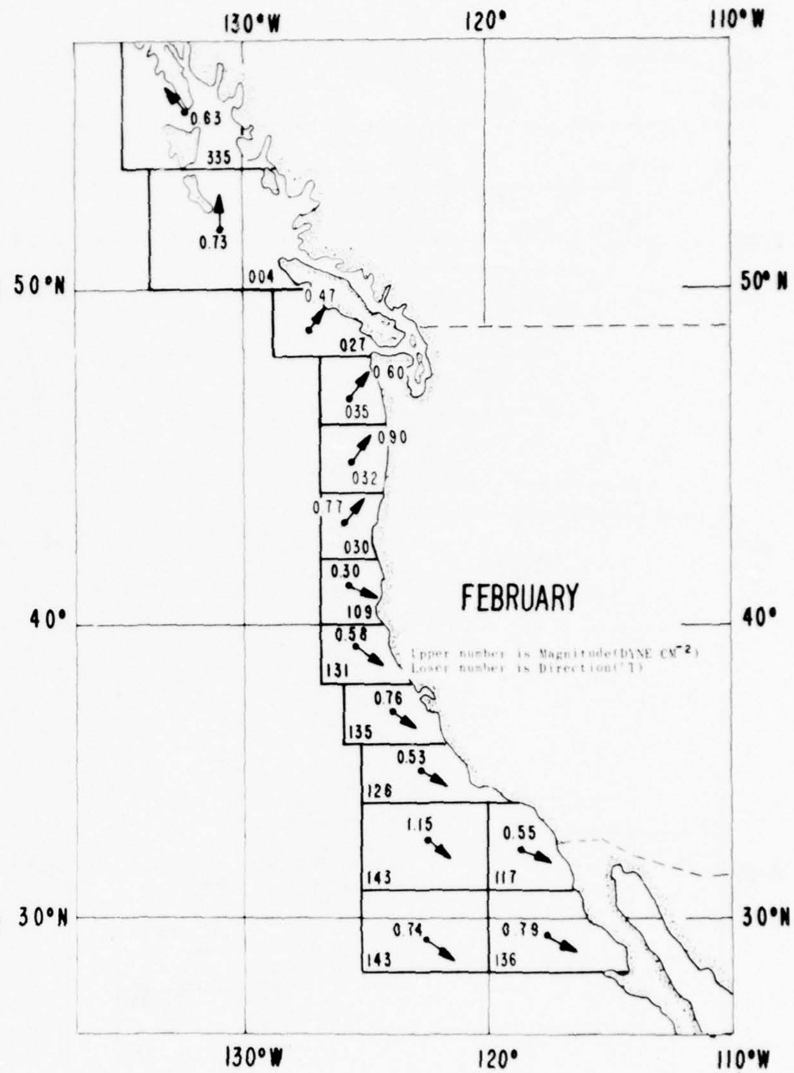


13. West Coast Average January Wind Stress (dynes/cm^2) and Direction (°).



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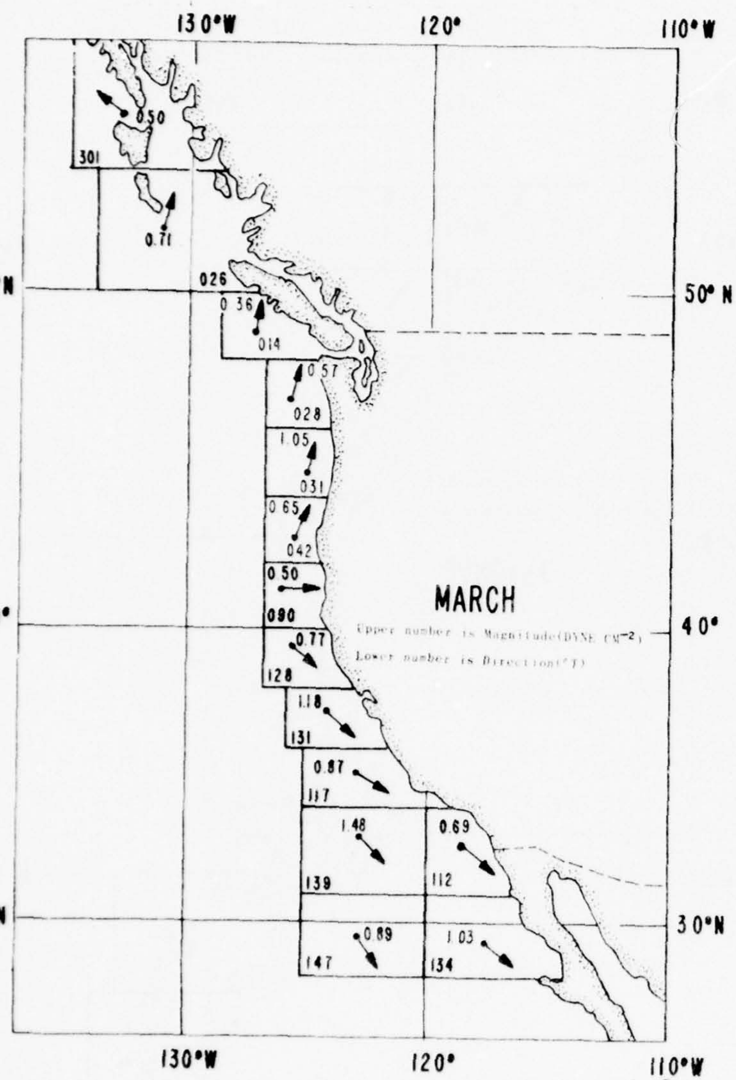

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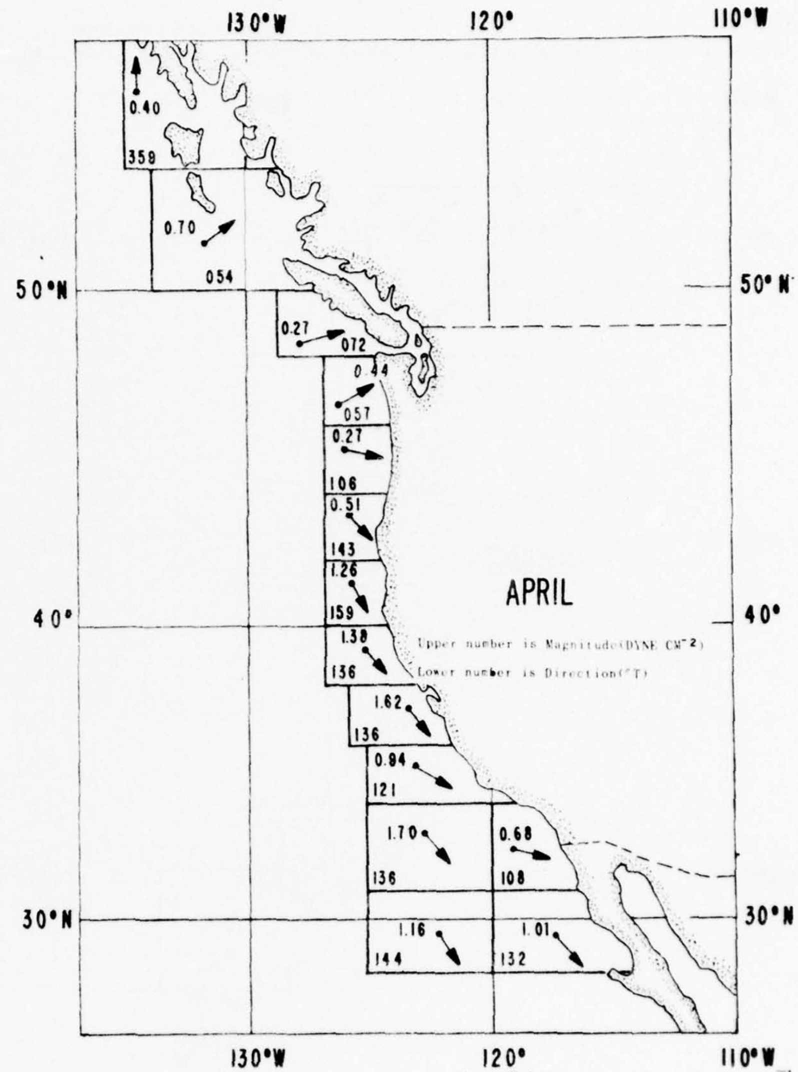

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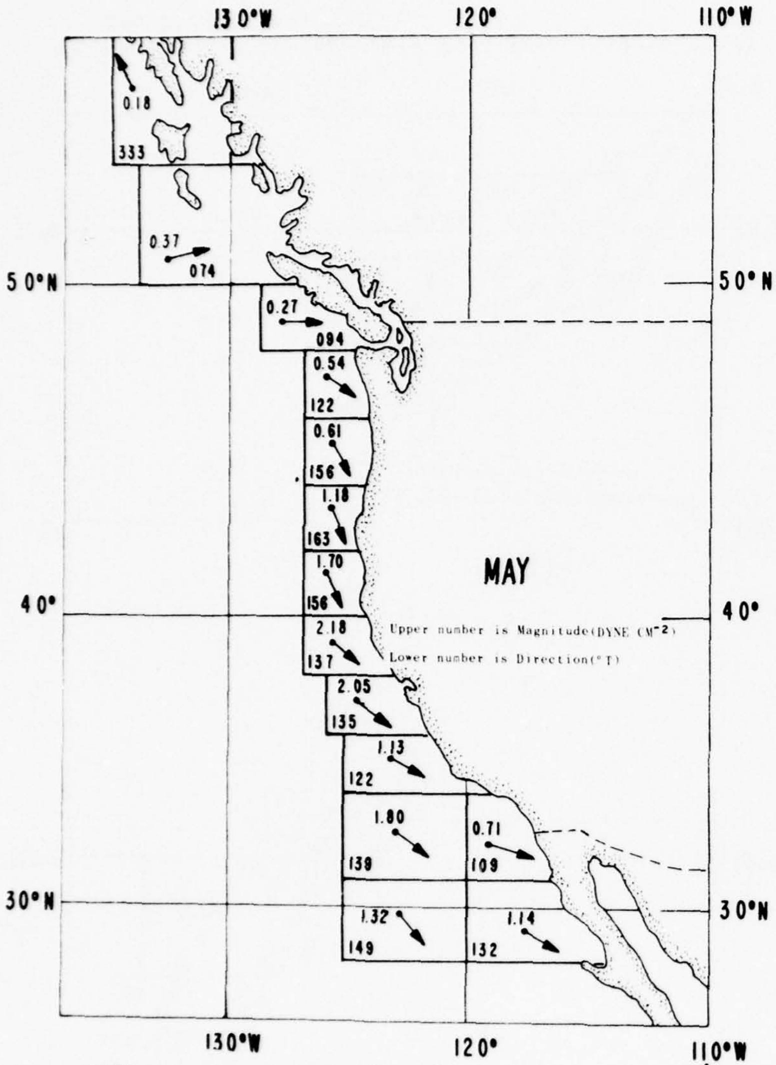
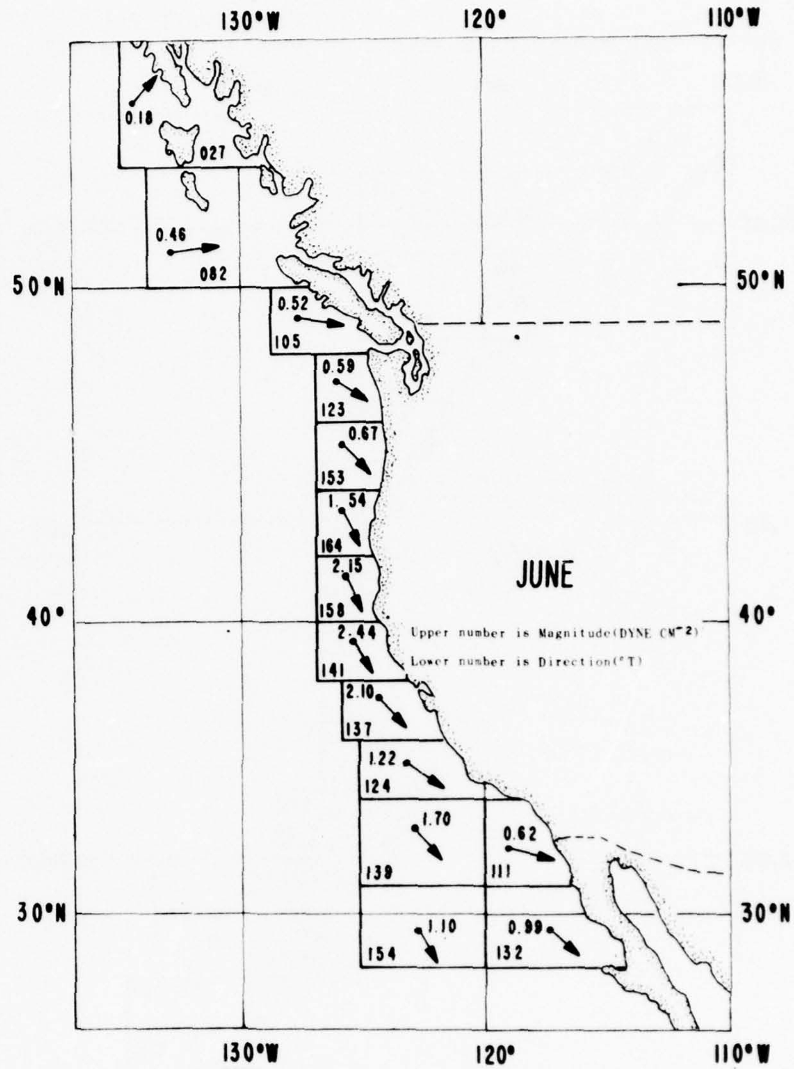


17. West Coast Average May Wind Stress (dynes/cm^2) and Direction (°).



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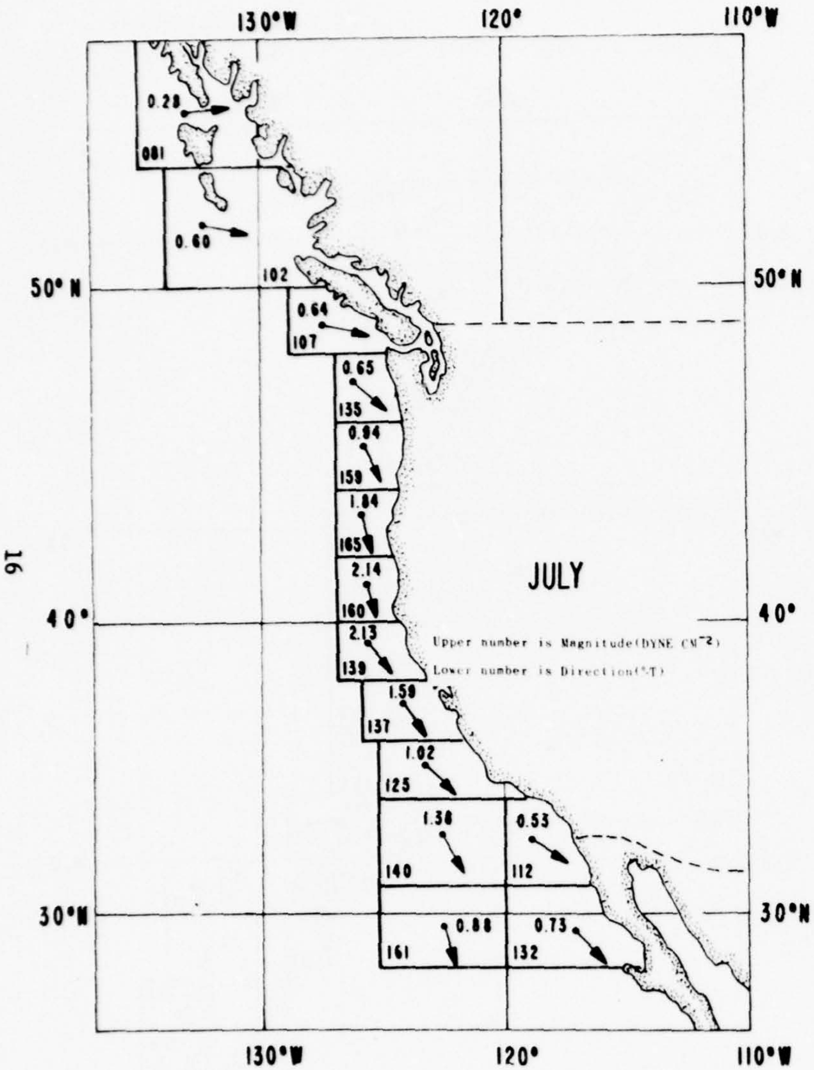

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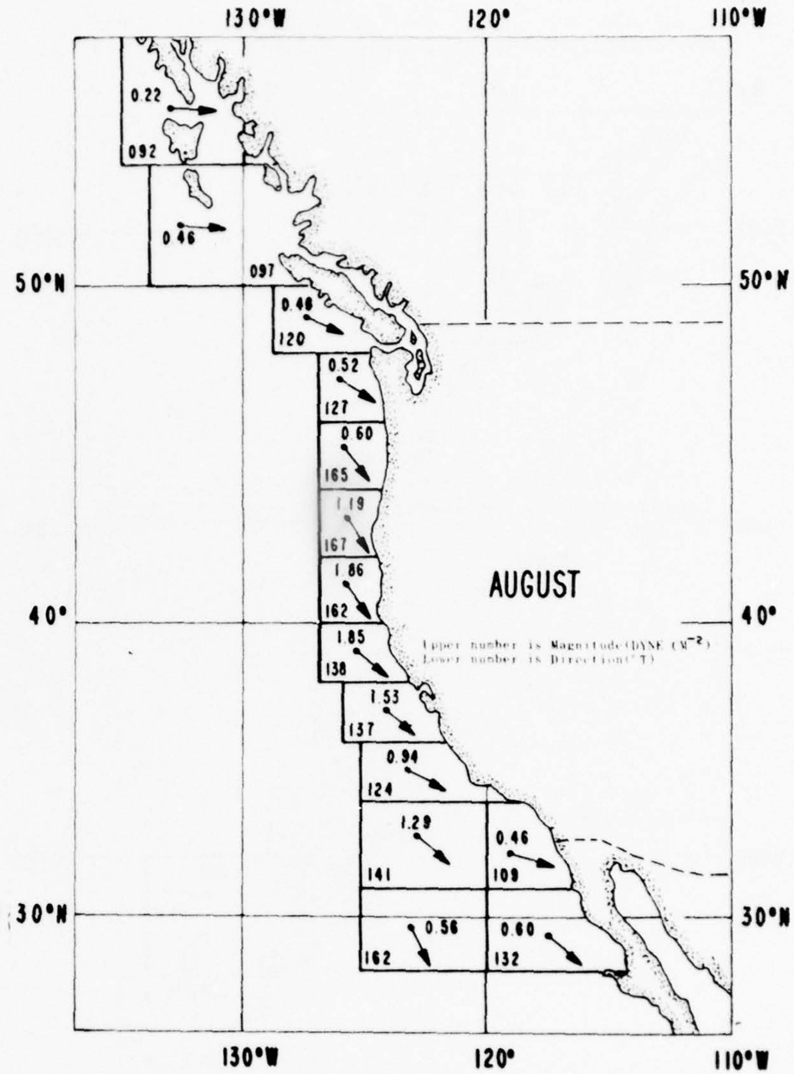

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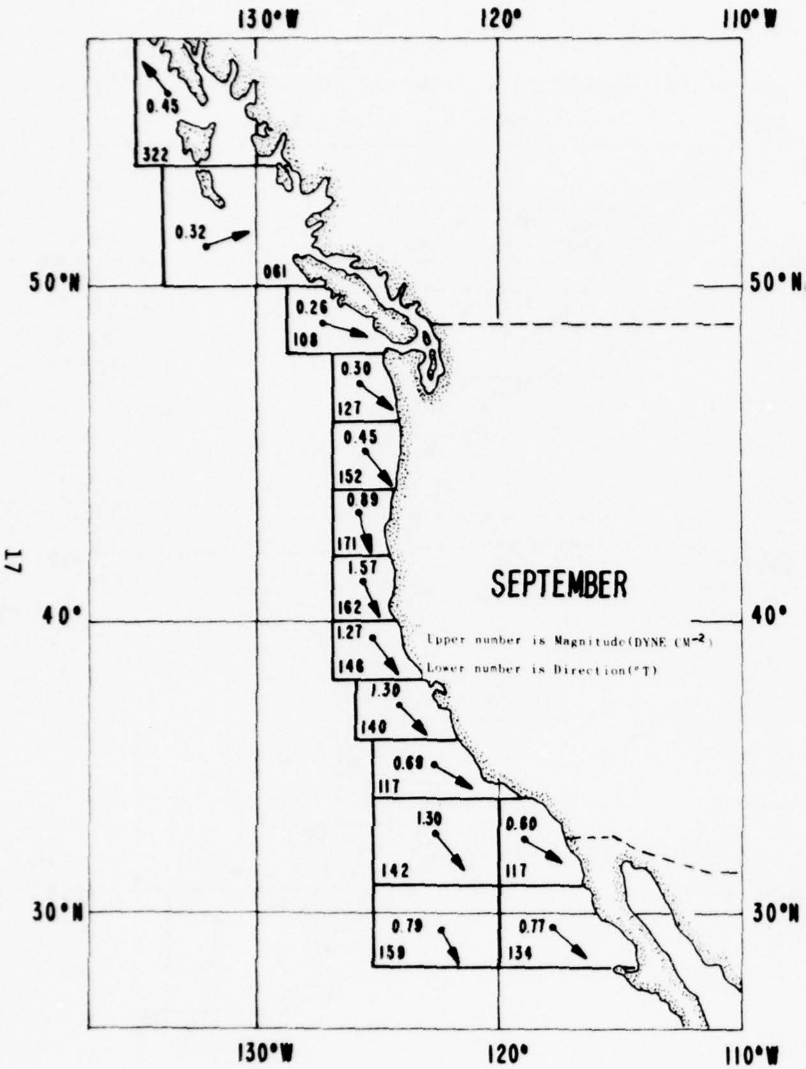
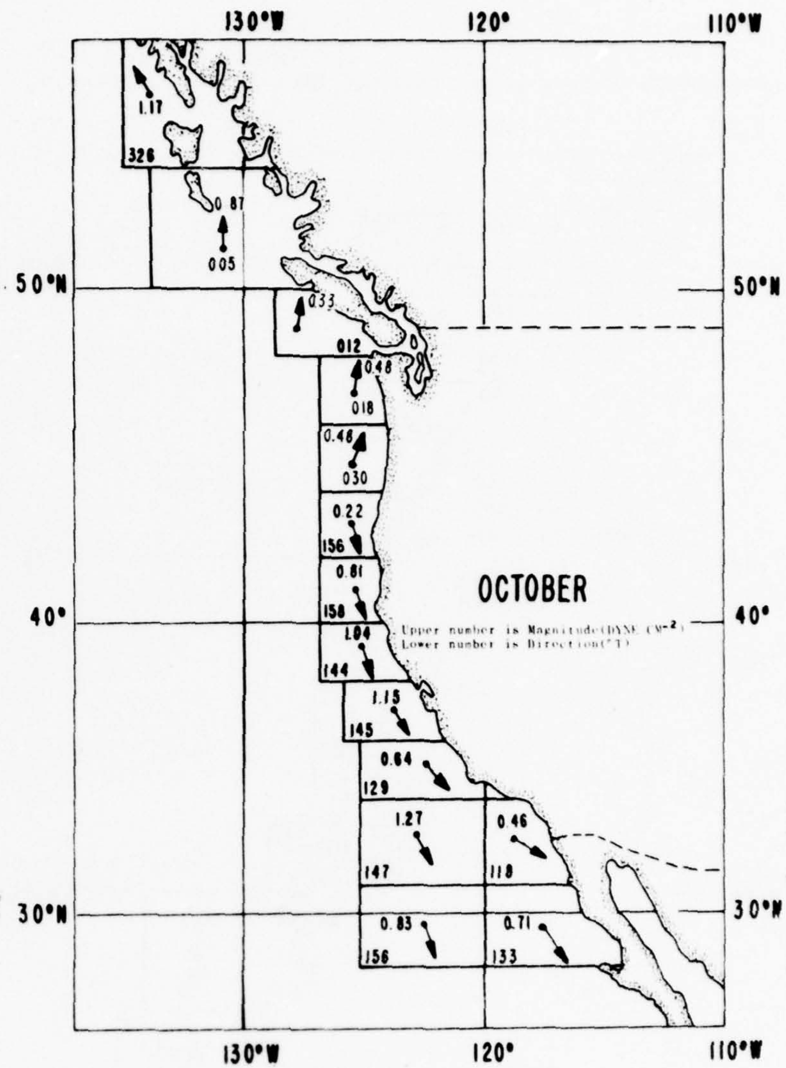


21. West Coast Average September Wind Stress (dynes/cm^2) and Direction (°).



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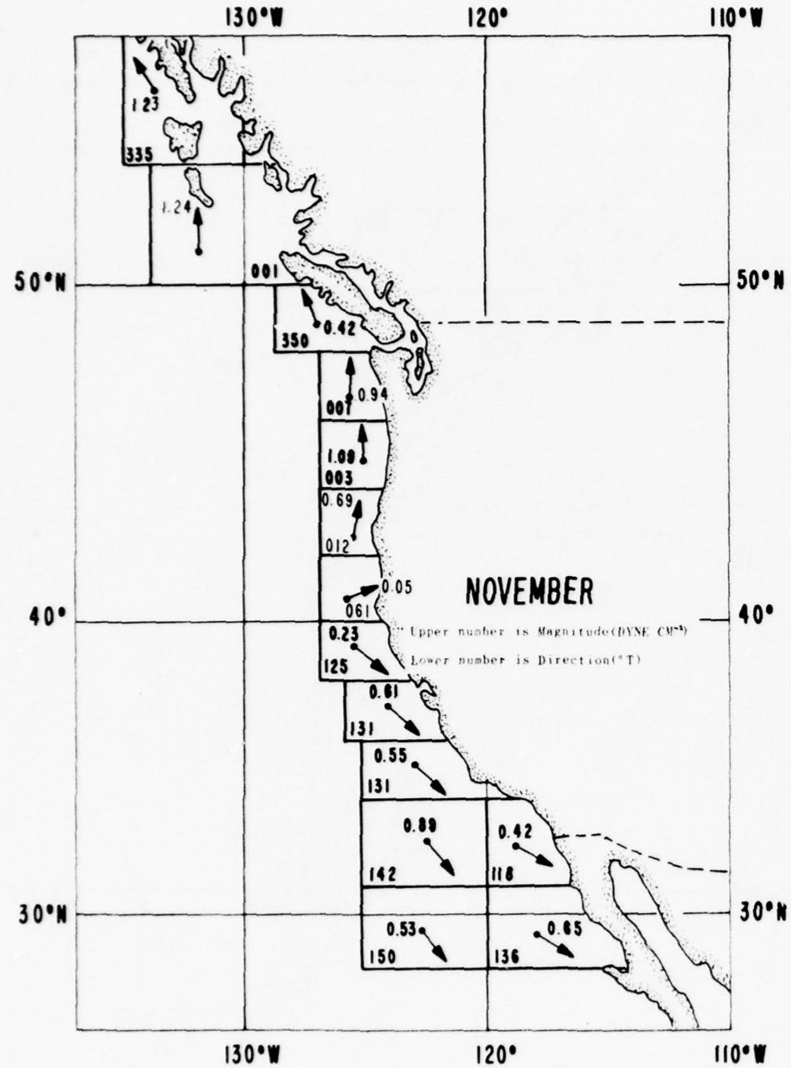
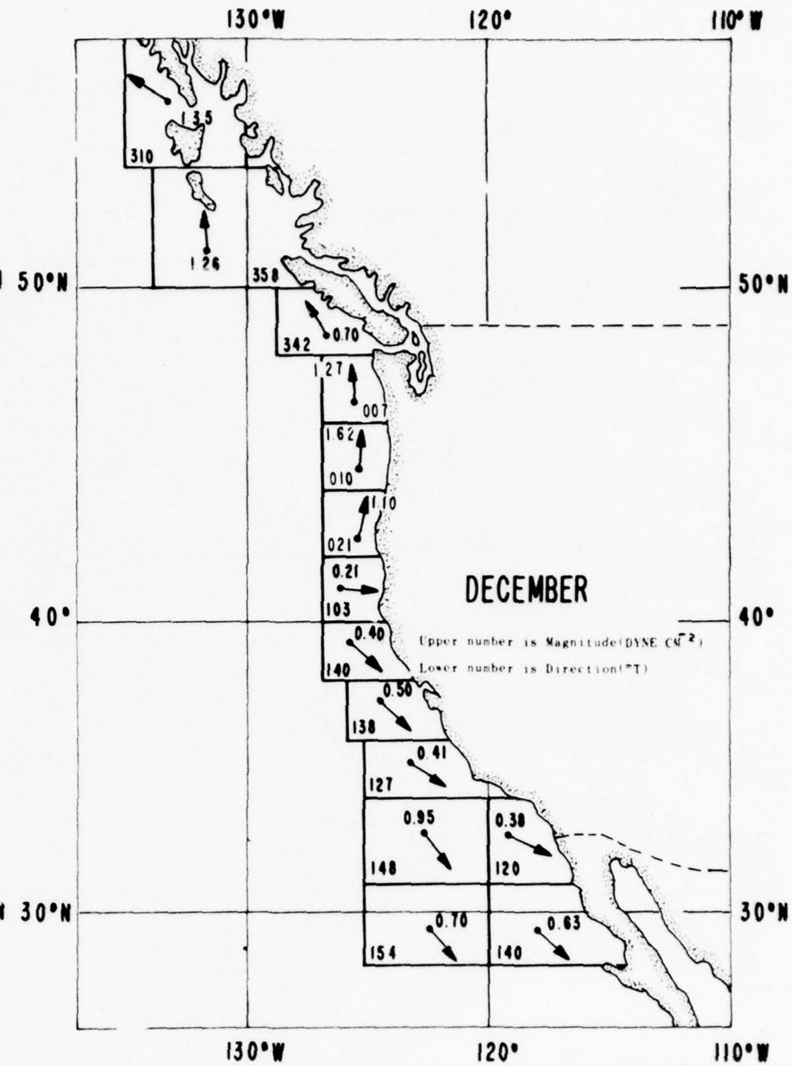
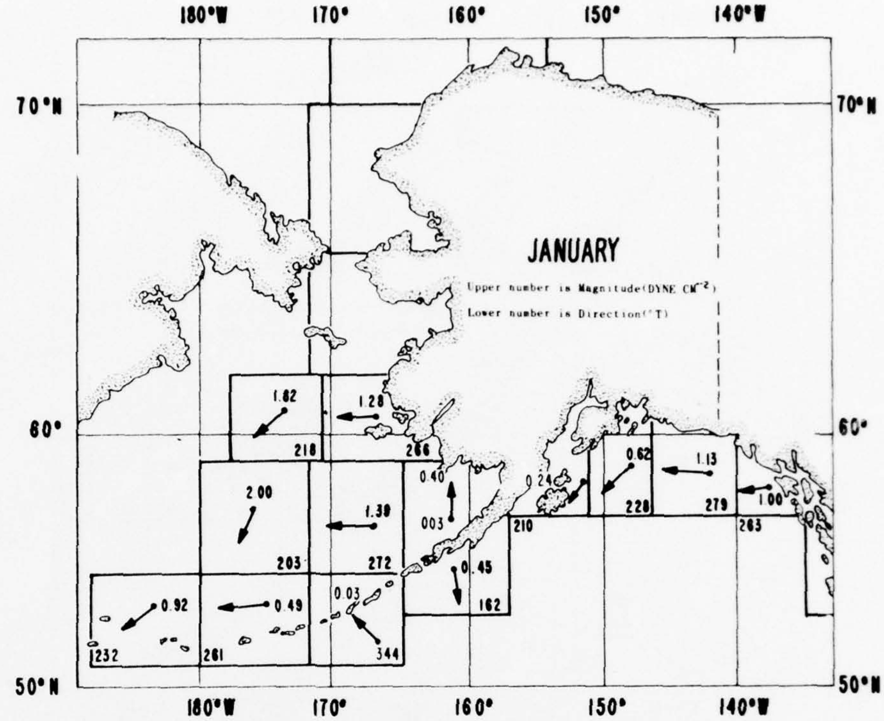


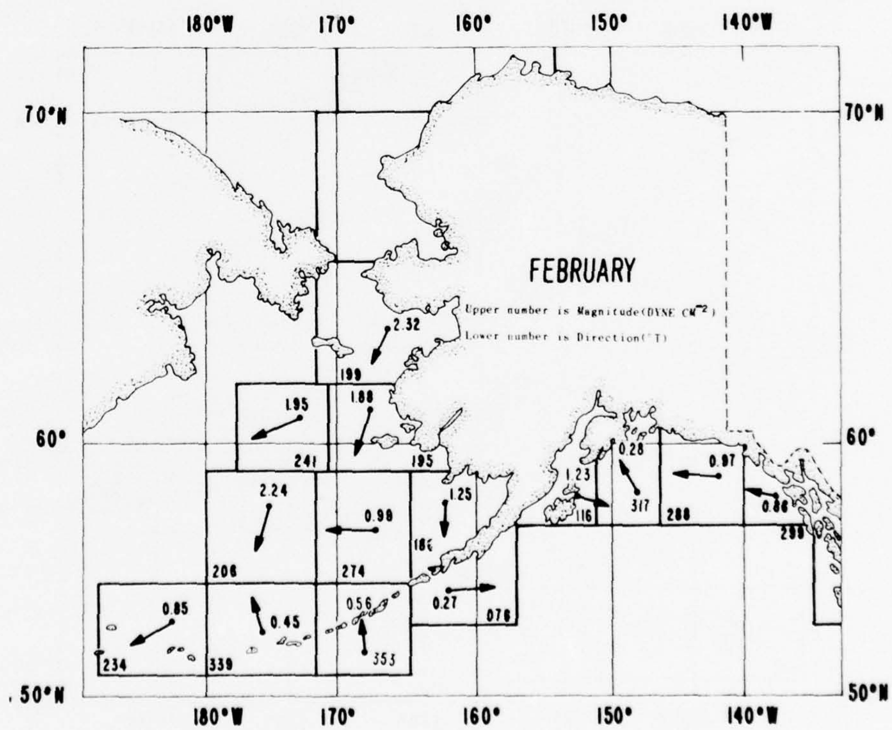
23. West Coast Average November Wind Stress (dynes/cm^2) and Direction (°).



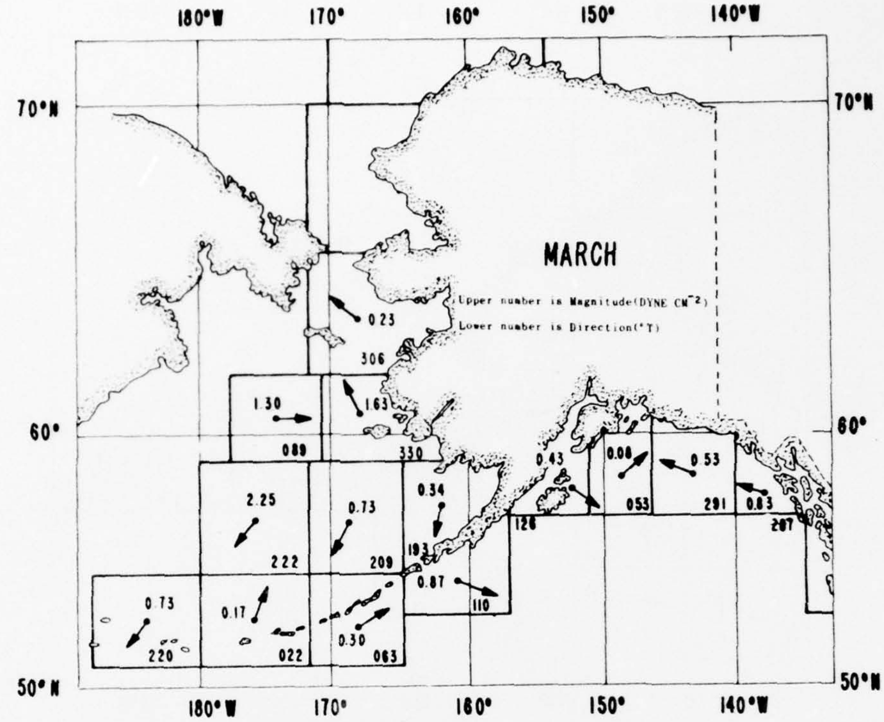
24. West Coast Average December Wind Stress (dynes/cm^2) and Direction (°).



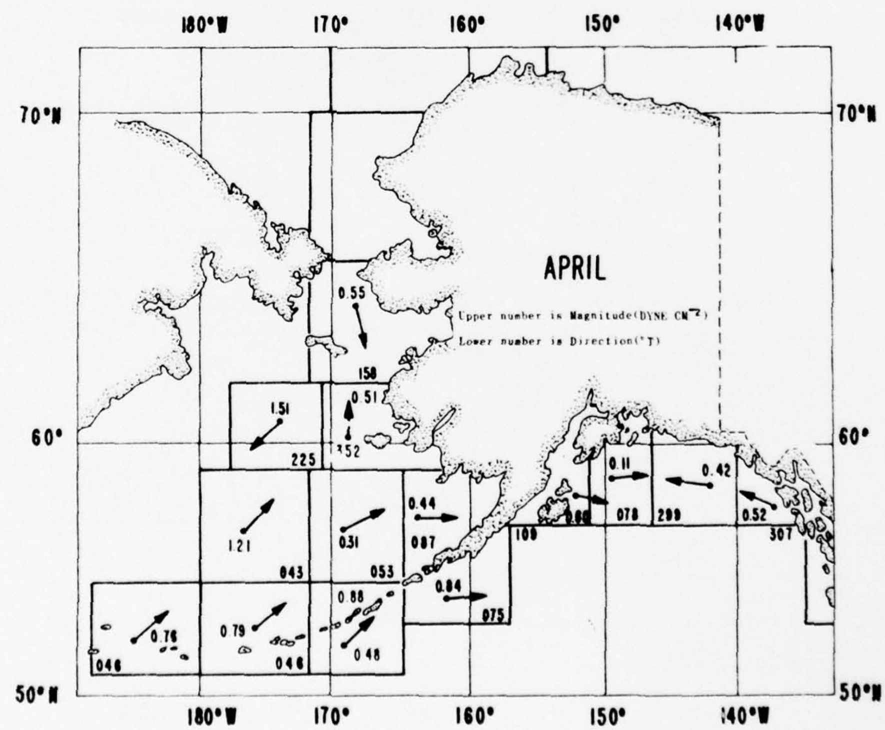
25. Alaskan Coast January Wind Stress (dynes/cm^2) and Direction°)



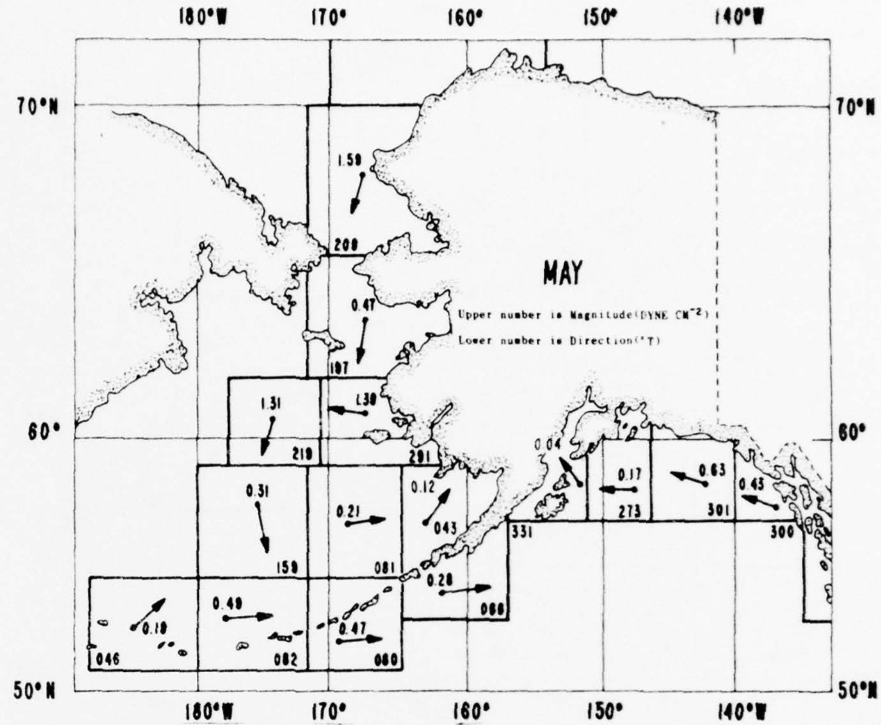
26. Alaskan Coast February Wind Stress (dynes/cm^2) and Direction°)



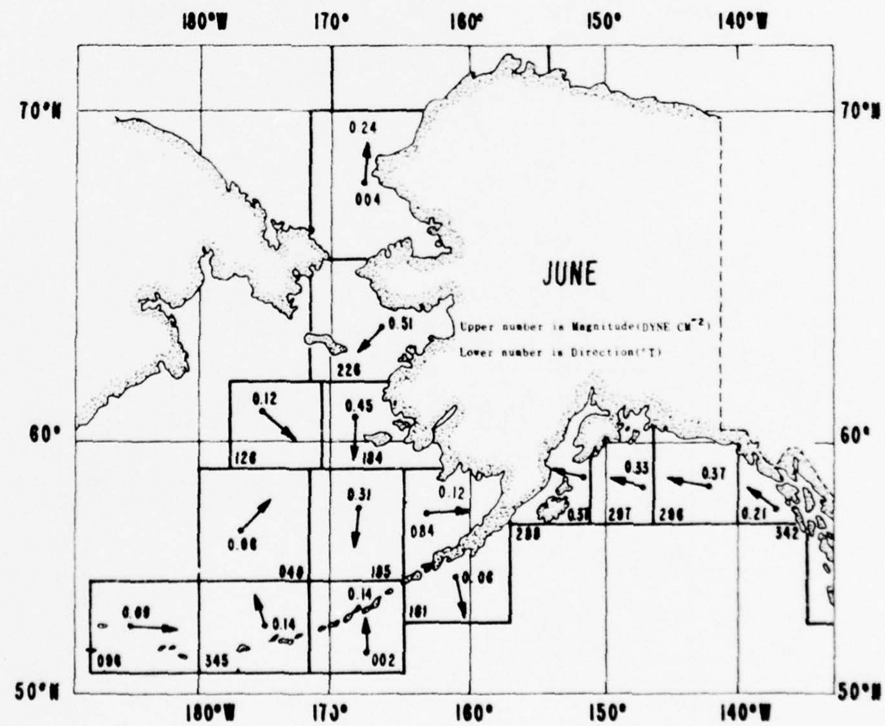
27. Alaskan Coast March Wind Stress (dynes/cm^2) and Direction°)



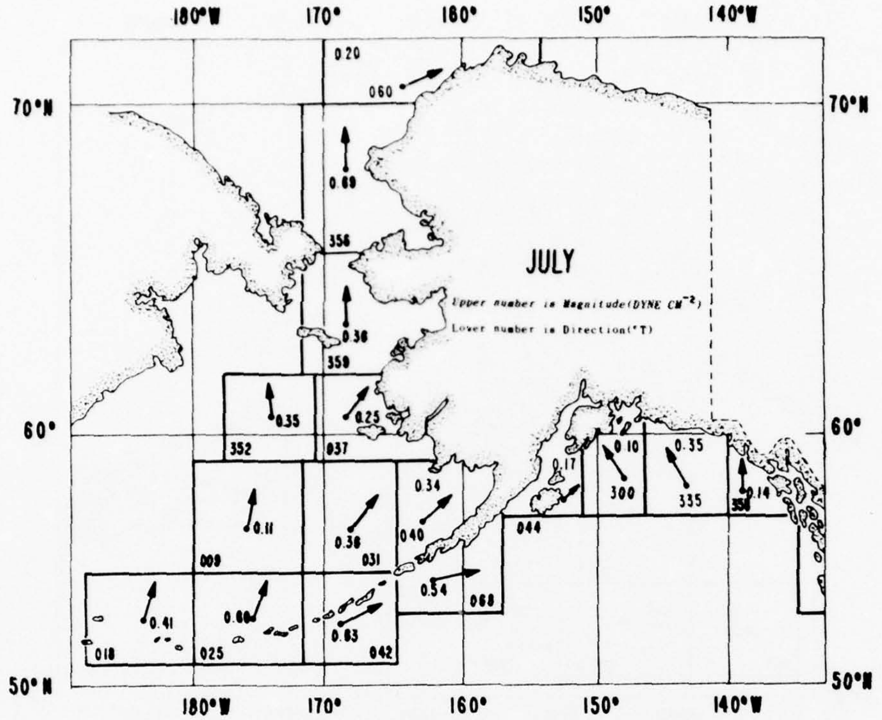
28. Alaskan Coast April Wind Stress (dynes/cm^2) and Direction°)



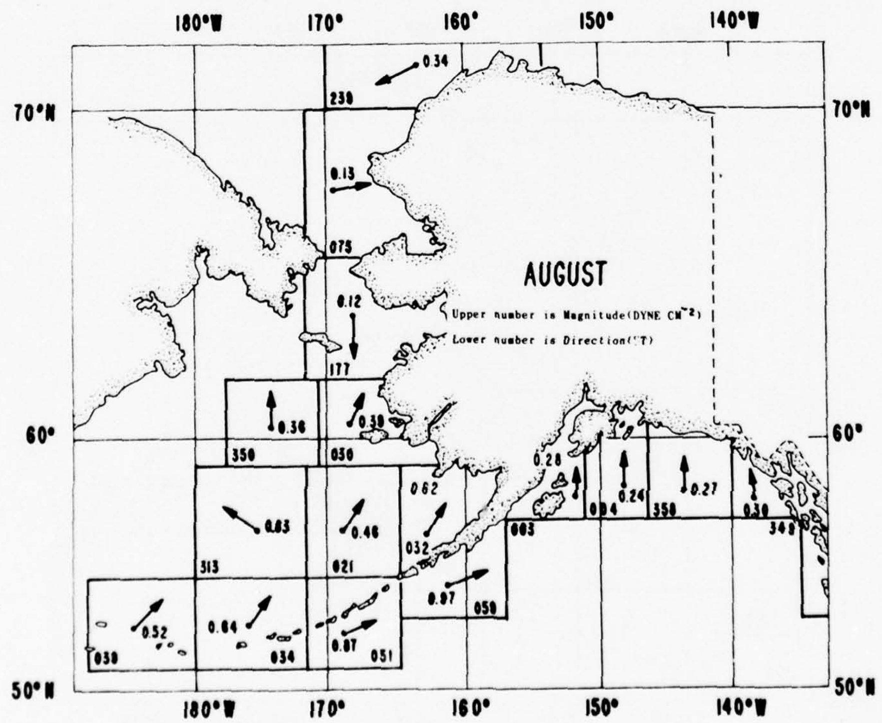
29. Alaskan Coast May Wind Stress (dynes/cm^2) and Direction °)



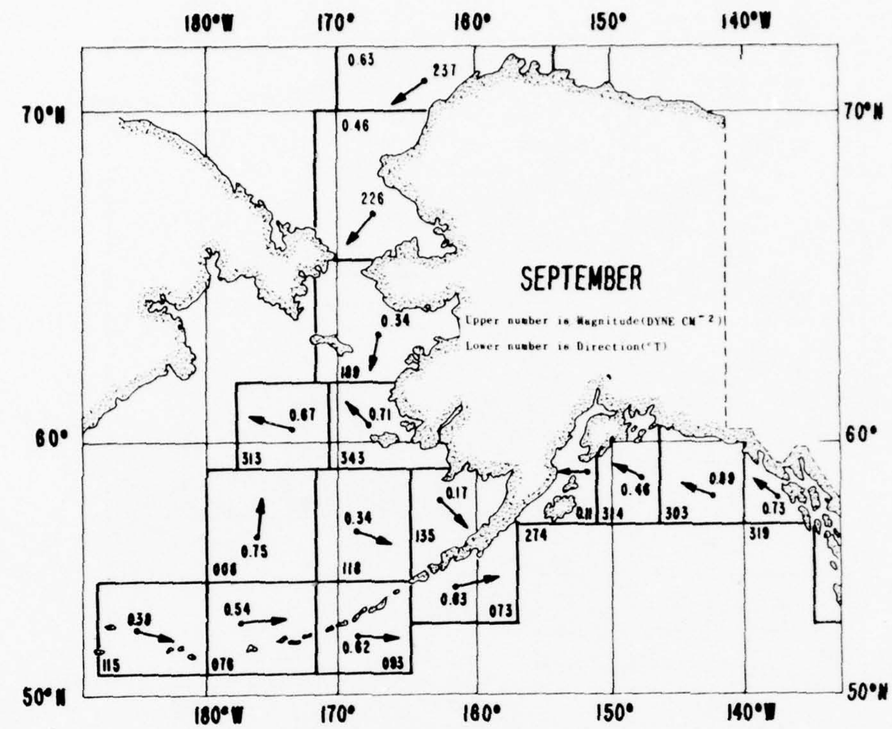
30. Alaskan Coast June Wind Stress (dynes/cm^2) and Direction °)



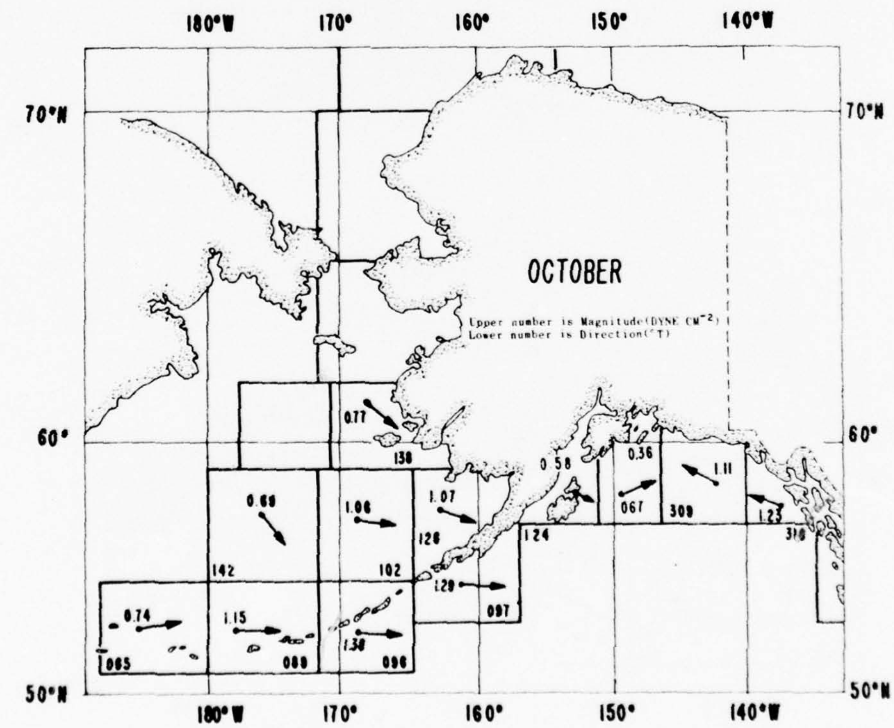
31. Alaskan Coast July Wind Stress (dynes/cm ^{2}) and Direction °)



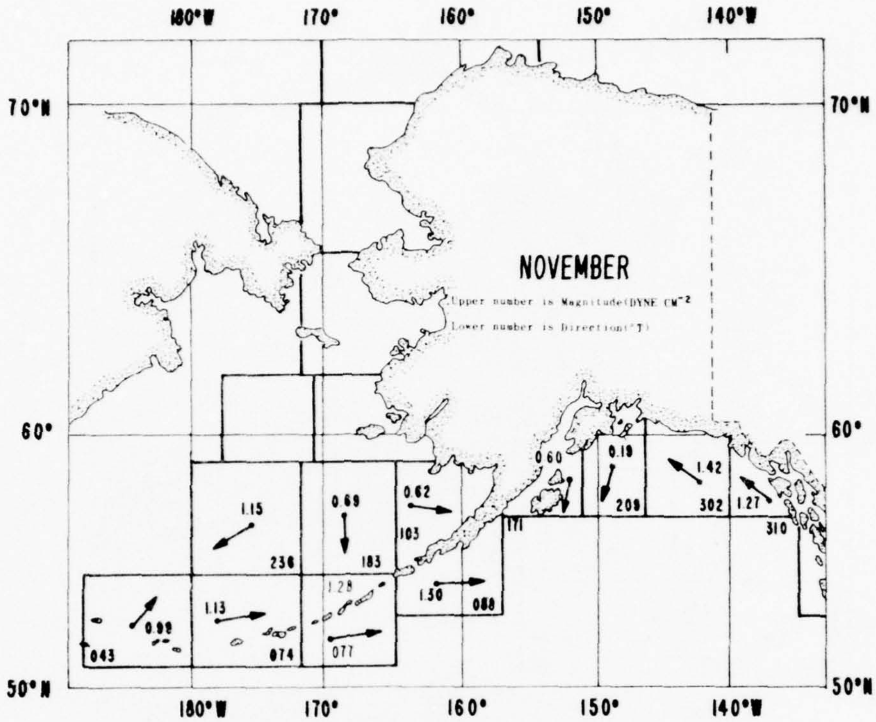
32. Alaskan Coast August Wind Stress (dynes/cm ^{2}) and Direction °)



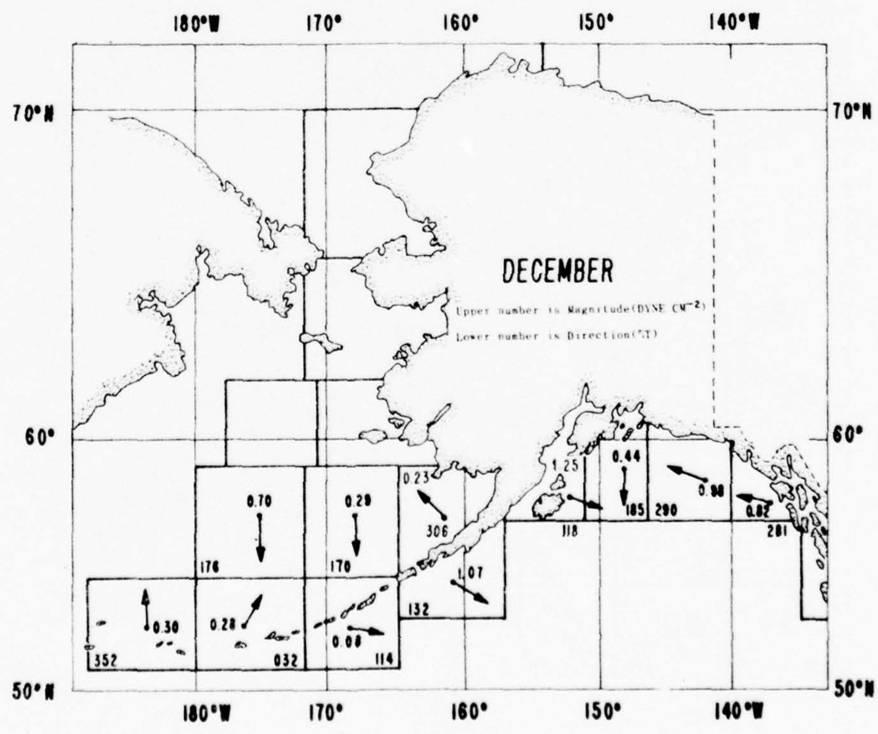
33. Alaskan Coast September Wind Stress (dynes/cm²) and Direction°)



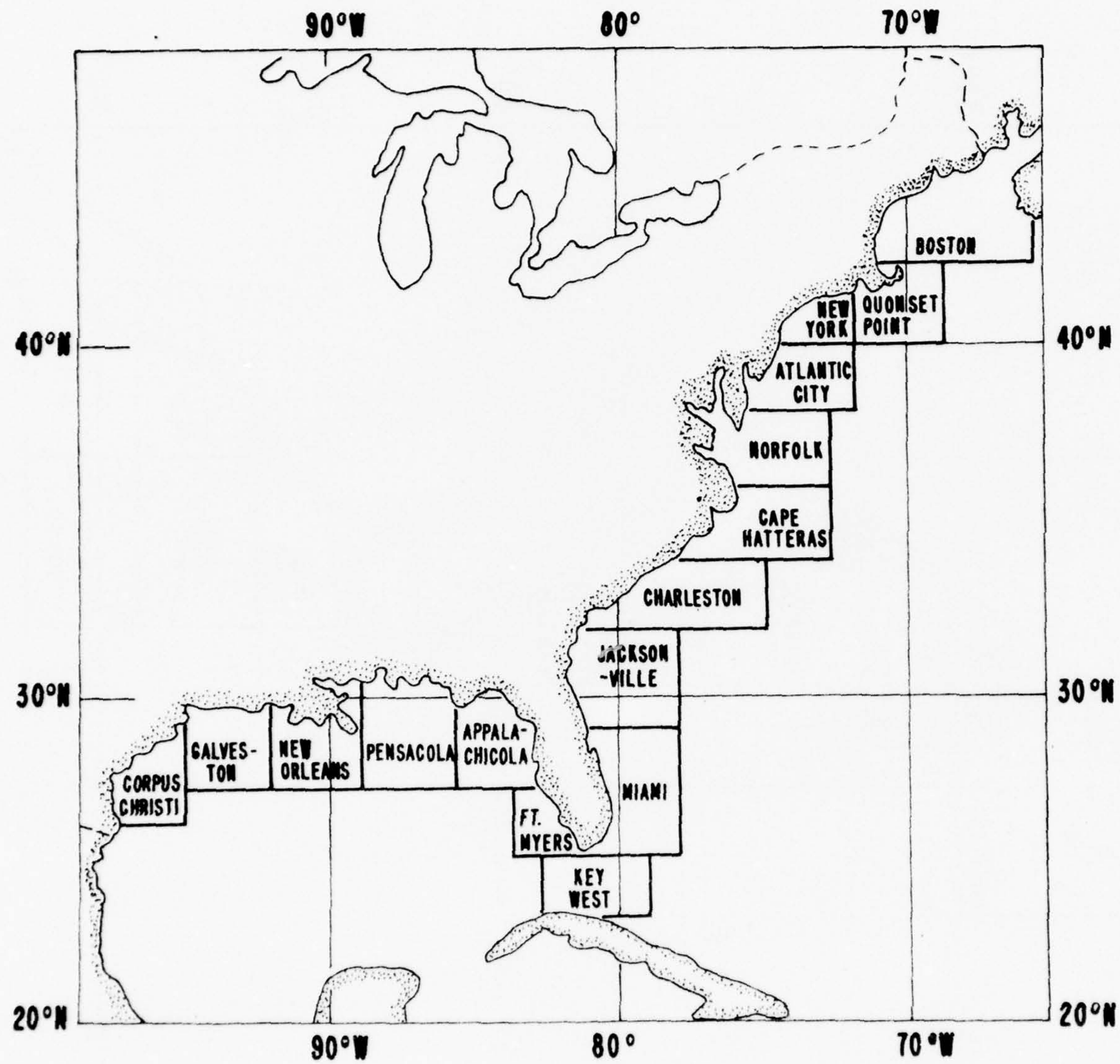
34. Alaskan Coast October Wind Stress (dynes/cm²) and Direction°)



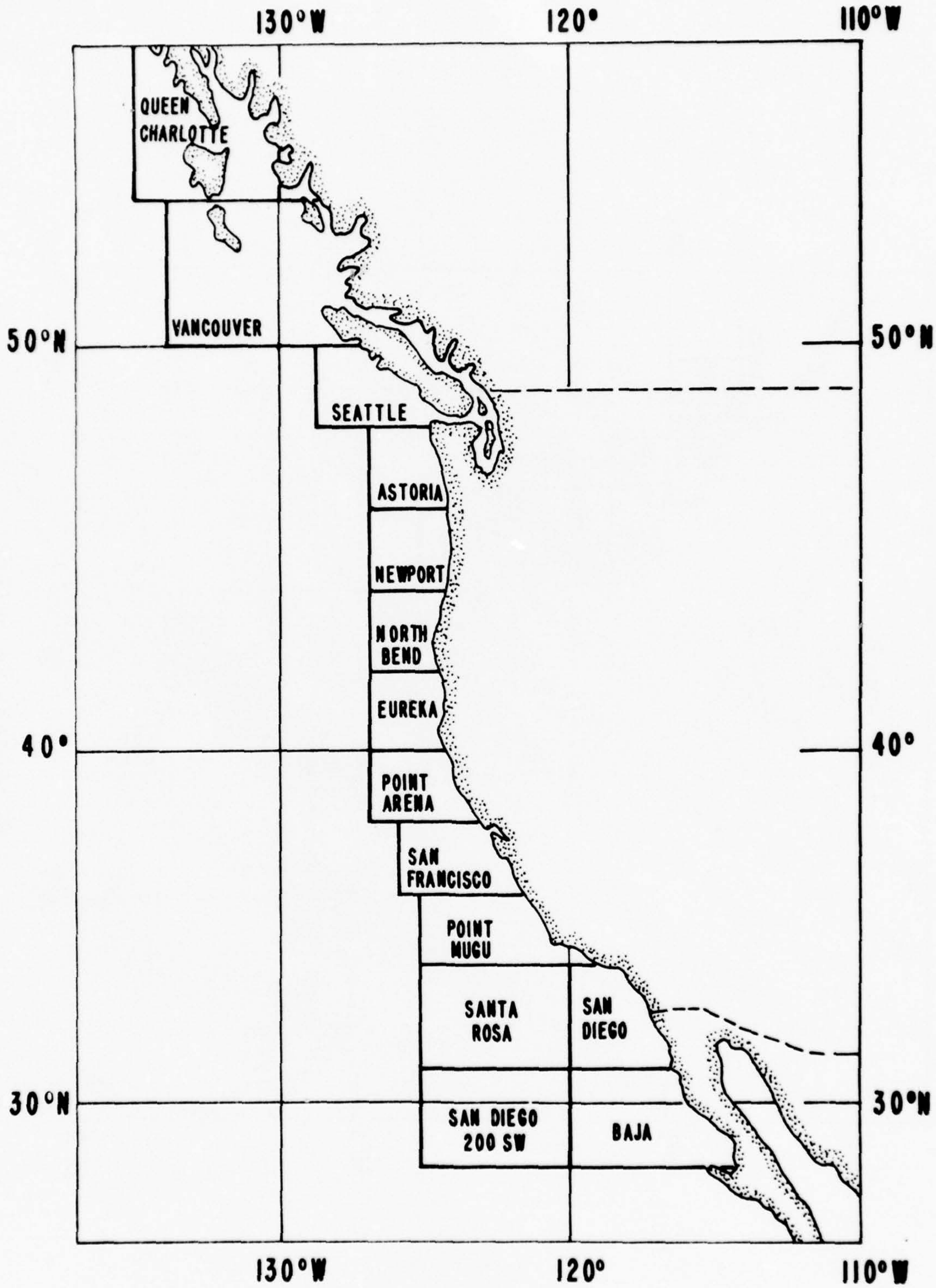
35. Alaskan Coast November Wind Stress (dynes/cm^2) and Direction°)



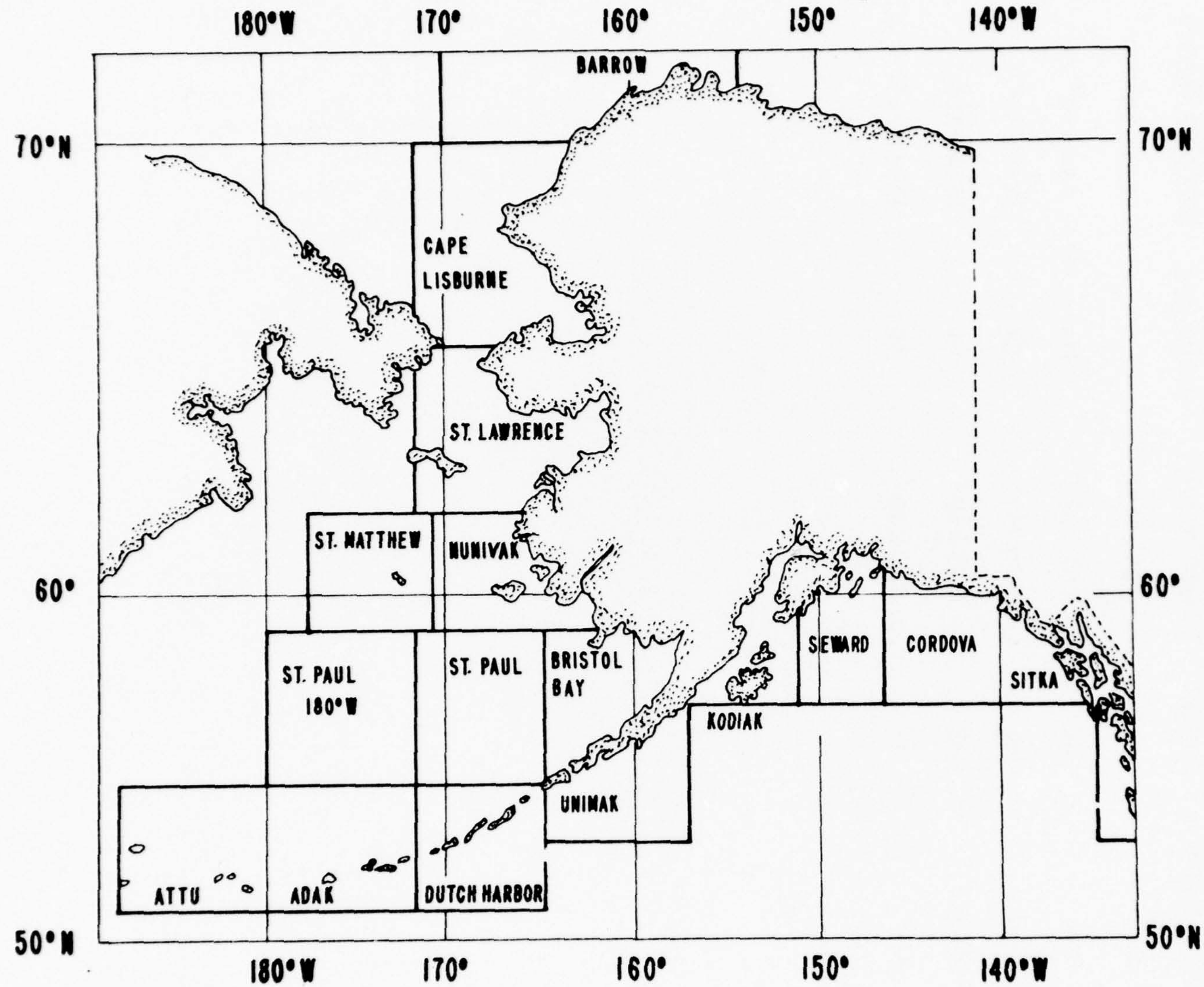
36. Alaskan Coast December Wind Stress (dynes/cm2) and Direction°)



37. East Coast Locator Chart.



38. West Coast Locator Chart.



39. Alaskan Coast Locator Chart.

TABLE 1

WIND SPEED INTERVALS

WIND SPEED INTERVAL (KTS)	BEAUFORT FORCE	DRAG COEFFICIENT	AVERAGE SPEED (Kn)	AVERAGE SPEED^2(CM^{2}SEC^{-2})
0-6	0-2	0.85×10^{-3}	3	0.24×10^5
7-16	3-4	1.09×10^{-3}	11.5	3.49×10^5
17-27	5-6	2.2×10^{-3}	22	12.79×10^5
28-40	7-8	2.43×10^{-3}	34	30.54×10^5
41+	9+	2.43×10^{-3}	41	44.41×10^5

TABLE 2
NUMBER OF OBSERVATIONS

	January	July		January	July
Boston	2558	2732	Eureka	499	769
Quonset Point	3374	3621	North Bend	469	527
New York	1183	1308	Newport	614	533
Atlantic City	4417	4553	Astoria	696	686
Norfolk	9784	9424	Seattle	1501	2083
Cape Hatteras	8209	8392	Vancouver	1035	1916
Charleston	9208	9439	Queen Charlotte	426	816
Jacksonville	7139	7680	Sitka	631	1044
Miami	9282	10007	Cordova	674	785
Key West	6067	6709	Seward	485	799
Fort Myers	722	804	Kodiak	454	1005
Apalachicola	579	689	Unimak	1112	2505
Pensacola	4801	5757	Dutch Harbor	2300	3572
New Orleans	6512	7253	Adak	1317	3006
Galveston	3886	4479	Attu	840	2757
Corpus Christi	1068	1109	Bristol Bay	371	2912
Baja	3272	3336	St. Paul	551	2508
San Diego, 200SW	508	517	St. Paul, 180W	265	1048
San Diego	6736	5945	Nunivak	62	739
Santa Rosa	3520	3235	St. Matthew	221	240
Point Mugu	3104	3726	St. Lawrence	No Data	1563
San Francisco	3047	3446	Cape Lisburne	No Data	1211
Point Arena	1054	1930	Barrow	No Data	2600

```
$JOB,42483,TAUCM-SF,4,20000
$SCHED,CORE=40,TIME=1,CLASS=C,SCR=2
$MAP=:
$FTNU(L,X)
      PROGRAM TAUCOM
C     THIS DIMENSIONS THE  FREQUENCY  OF EACH WIND SPEED AND THE EIGHT
C     TAU STRESSES
      DIMENSION FA(8),FB(8),FC(8),FD(8),FE(8),       T(8),DIR(8)
      REAL LAT
      WRITE(61,6)
    6 FORMAT(1H1)
    1 ICOUNT=0
      READ(60,5) LAT
    5 FORMAT(F4.1)
    2 JCOUNT=0
      IF(LAT.EQ.99. ) GO TO 11
   10 DO 20 I=1,8
      READ(60,100)FA(I),FB(I),FC(I),FD(I),FE(I),       ID
  100 FORMAT(5(F3.3,1X),56X,A4)
   20 CONTINUE
C     THESE ARE THE AVERAGE WIND SPEEDS FROM TABLE 3A OF THE SSMO UA(3 KTS),
C     UB(11.5 KTS), UC(22 KTS), UD(34 KTS), AND UE(41+ KTS) THESE SPEEDS ARE IN
C     CM2 / SEC2
      UA=23777.6
      UB=349399.2
      UC=1278708.6
      UD=3054105.8
      UE=4441134.8
      RHO=(0.0022*LAT+1.136)*.001
      CA=0.00085
      CB=0.00109
      CC=0.00220
      CD=0.00243
      QA=RHO*CA
      QB=RHO*CB
      QC=RHO*CC
      QD=RHO*CD
      DO 103 K=1,8
C     T(K) IS THE STRESS FOR ANY DIRECTION K  WHERE K IS THE EIGHT CARDINAL
C     DIRECTIONS NUMBERED 1 THRU 8
  103 T(K)=(QA*(FA(K)*UA))+(QB*(FB(K)*UB))+(QC*(FC(K)*UC))+
     1(QD*(FD(K)*UD))+(QD*(FE(K)*UE))
C     YU IS THE SUM OF ALL STRESSES IN THE Y DIRECTION
C     POSITIVE NUMBERS ARE EQUAL TO TRUE NORTH AND NEGATIVE NUMBERS ARE IN THE
C     SOUTHERLY DIRECTION
      YU=T(1)+.707*T(2)-.707*T(4)-T(5)-.707*T(6)+.707*T(8)
C     XU IS THE SUM OFSTRESSES IN THE EAST OR WEST DIRECTION
      XU=.707*T(2)+T(3)+.707*T(4)-.707*T(6)-T(7)-.707*T(8)
      XS=XU
      YS=YU
      IF(YU.LT.0.) YU=-YU
      IF(XU.LT.0.) XU=-XU
      DIRVT=XU/YU
      DIRVC=ATAN(DIRVT)*57.2958
      SPDVT=SQRT((XU**2)+(YU**2))
      IF(XS.GE.0..AND.YS.LT.0.) GO TO 91
      IF(XS.LT.0..AND.YS.LT.0.) GO TO 92
      IF(XS.LT.0..AND.YS.GE.0.) GO TO 93
      DIRVE=DIRVC
      GO TO 1000
   91 DIRVE=180.-DIRVC
      GO TO 1000
   92 DIRVE=DIRVC+180.
```

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```
      GO TO 1000
   93 DIRVE=360.-DIRVC
 1000 CONTINUE
      WRITE(61,7) LAT,RHO
    7 FORMAT(1H ,*LATITUDE*,1X,F4.1,10X,*RHO =*,F11.9)
      WRITE(61,8) QA
    8 FORMAT(1H ,*QA =*,F11.9)
      WRITE(61,9) QB
    9 FORMAT(1H ,*QB =*,F11.9)
      WRITE(61,21) QC
   21 FORMAT(1H ,*QC =*,F11.9)
      WRITE(61,22) QD
   22 FORMAT(1H ,*QD =*,F11.9)
      WRITE(61,24)
   24 FORMAT(1H ,33X,*FREQUENCY PERCENT*)
      WRITE(61,26)
   26 FORMAT(1H ,12X,*FA*,8X,*FB*,8X,*FC*,9X,*FD*,7X,*FF*,10X,*TAU*,
     114X,*MONTH*)
      DO 501 I=1,8
      WRITE(61,101) I,FA(I),FB(I),FC(I),FD(I),FF(I),T(I),ID
  101 FORMAT(1H ,5X,I1  ,5X, 5(F5.3,5X),F12.8,10X,A4)
  501 CONTINUE
      WRITE(61,502)XS,YS,SPDVT,DIRVE
  502 FORMAT(1H/,/,5X,12HX COORDINATE,1X,F10.5,5X,12HY COORDINATE,F10.5,
     15X,13HTOT STRESS IS,F15.8,1X, 6HIN THE,1X,F4.0,1X,9HDIRECTION
     1,//)
      JCOUNT=JCOUNT+1
      IF(JCOUNT.EQ.3) GO TO 23
      GO TO 25
   23 WRITE(61,27)
   27 FORMAT(1H1)
   25 ICOUNT=ICOUNT+1
      IF(ICOUNT.EQ.12) GO TO 1
      IF(JCOUNT.EQ.3) GO TO 2
      GO TO 10
   11 STOP
      END
          FINIS
308.J.LGO
99.
[[
```

APPENDIX B

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

BOSTON	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	1.13	-0.52	1.25	115
February	1.19	-0.52	1.30	114
March	0.97	-0.38	1.04	111
April	0.23	0.18	0.29	052
May	0.17	0.35	0.39	025
June	0.20	0.38	0.43	028
July	0.17	0.36	0.40	026
August	0.13	0.27	0.30	026
September	0.16	0.11	0.19	056
October	0.39	-0.06	0.40	099
November	0.68	-0.18	0.70	105
December	1.16	-0.40	1.23	109
QUONSET POINT				
January	1.20	-0.50	1.30	113
February	1.28	-0.46	1.36	110
March	0.78	-0.43	0.90	119
April	0.32	-0.08	0.33	105
May	0.13	0.10	0.16	053
June	0.15	0.19	0.24	039
July	0.12	0.23	0.26	028
August	0.07	0.10	0.12	037
September	0.02	-0.28	0.28	176
October	0.29	-0.42	0.51	145
November	0.77	-0.26	0.81	109
December	1.17	-0.53	1.29	114
NEW YORK				
January	0.83	-0.34	0.89	112
February	1.07	-0.52	1.19	116
March	0.47	-0.34	0.58	126
April	0.31	0.05	0.32	082
May	-0.06	0.21	0.22	345
June	0.01	0.18	0.18	004
July	0.08	0.27	0.28	018
August	0.01	0.07	0.07	010
September	-0.03	-0.16	0.17	192
October	0.16	-0.32	0.35	153
November	0.69	-0.06	0.70	095
December	1.11	-0.28	1.15	104

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

ATLANTIC CITY	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	1.04	-0.59	1.20	120
February	1.02	-0.48	1.13	115
March	0.63	-0.46	0.78	126
April	0.30	-0.03	0.30	096
May	0.01	0.10	0.10	006
June	0.02	0.15	0.15	009
July	0.10	0.27	0.29	020
August	-0.01	0.08	0.08	007
September	-0.03	-0.26	0.27	186
October	0.19	-0.52	0.56	160
November	0.78	-0.29	0.83	111
December	1.10	-0.41	1.17	110
NORFOLK				
January	0.87	-0.58	1.04	124
February	0.72	-0.44	0.84	122
March	0.61	-0.27	0.67	114
April	0.29	0.05	0.29	081
May	0.06	0.05	0.08	048
June	-0.09	0.07	0.12	308
July	0.06	0.25	0.26	013
August	-0.02	0.10	0.10	348
September	-0.18	-0.39	0.43	205
October	0.07	-0.64	0.64	174
November	0.56	-0.37	0.67	124
December	0.76	-0.42	0.87	119
CAPE HATTERAS				
January	1.06	-0.57	1.21	118
February	0.95	-0.31	1.00	108
March	0.80	-0.19	0.82	103
April	0.56	0.11	0.57	079
May	0.06	0.08	0.10	037
June	0.01	0.16	0.16	005
July	0.23	0.43	0.49	028
August	0.03	0.21	0.21	008
September	-0.28	-0.47	0.55	210
October	-0.22	-0.76	0.79	197
November	0.49	-0.52	0.72	137
December	0.77	-0.39	0.86	117

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

CHARLESTON	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	0.81	-0.33	0.88	112
February	0.70	-0.16	0.72	103
March	0.61	-0.06	0.62	095
April	0.33	0.19	0.38	060
May	-0.05	0.07	0.09	327
June	-0.03	0.17	0.18	349
July	0.17	0.47	0.50	020
August	-0.03	0.16	0.16	348
September	-0.47	-0.46	0.66	226
October	-0.31	-0.94	0.99	199
November	0.24	-0.45	0.51	152
December	0.55	-0.34	0.64	122
JACKSONVILLE				
January	0.57	-0.42	0.70	126
February	0.56	-0.16	0.58	106
March	0.43	-0.14	0.46	107
April	0.11	-0.01	0.11	094
May	-0.13	-0.02	0.13	262
June	-0.12	0.09	0.15	308
July	0.05	0.27	0.27	010
August	-0.05	-0.003	0.05	266
September	-0.54	-0.39	0.67	234
October	-0.47	-0.91	1.03	207
November	-0.01	-0.66	0.66	180
December	0.31	-0.45	0.54	145
MIAMI				
January	0.10	-0.31	0.32	162
February	0.13	-0.11	0.17	130
March	0.01	-0.08	0.08	169
April	-0.25	-0.07	0.26	255
May	-0.29	-0.04	0.29	261
June	-0.18	0.14	0.23	308
July	-0.16	0.18	0.25	318
August	-0.10	0.02	0.11	282
September	-0.36	-0.13	0.38	250
October	-0.47	-0.60	0.76	218
November	-0.28	-0.56	0.63	206
December	-0.07	-0.44	0.45	189

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

KEY WEST	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	-0.50	-0.42	0.65	230
February	-0.37	-0.25	0.44	235
March	-0.48	-0.20	0.52	248
April	-0.66	-0.17	0.68	256
May	-0.52	-0.08	0.53	261
June	-0.43	0.08	0.44	281
July	-0.42	0.04	0.42	276
August	-0.35	0.02	0.35	273
September	-0.45	0.02	0.45	273
October	-0.52	-0.38	0.65	234
November	-0.61	-0.57	0.83	227
December	-0.64	-0.54	0.83	230
FORT MYERS				
January	-0.13	-0.41	0.43	198
February	-0.24	-0.24	0.34	224
March	-0.11	-0.20	0.23	209
April	-0.43	-0.09	0.44	258
May	-0.30	-0.04	0.31	262
June	-0.26	0.05	0.26	281
July	-0.21	0.07	0.22	288
August	-0.17	0.05	0.18	285
September	-0.33	0.07	0.34	282
October	-0.50	-0.43	0.66	229
November	-0.35	-0.63	0.72	209
December	-0.35	-0.44	0.56	219
APALACHICOLA				
January	0.21	-0.43	0.47	154
February	0.00	-0.30	0.30	180
March	0.06	-0.14	0.16	157
April	-0.16	-0.11	0.19	236
May	-0.22	-0.03	0.22	263
June	-0.13	0.06	0.14	293
July	-0.05	0.11	0.12	337
August	-0.16	0.08	0.18	299
September	-0.60	0.02	0.60	272
October	-0.39	-0.50	0.63	218
November	-0.15	-0.39	0.42	201
December	-0.26	-0.44	0.51	210

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

PENSACOLA	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	0.00	-0.42	0.42	180
February	-0.08	-0.22	0.24	199
March	-0.21	-0.15	0.26	235
April	-0.27	0.05	0.28	281
May	-0.30	0.03	0.30	276
June	-0.19	0.16	0.25	312
July	-0.02	0.12	0.12	350
August	-0.11	0.09	0.14	312
September	-0.58	-0.05	0.59	265
October	-0.55	-0.46	0.72	230
November	-0.22	-0.49	0.53	204
December	-0.16	-0.35	0.38	204
NEW ORLEANS				
January	-0.06	-0.45	0.45	188
February	-0.20	-0.28	0.35	216
March	-0.27	-0.22	0.35	230
April	-0.39	0.07	0.39	281
May	-0.39	0.09	0.40	283
June	-0.24	0.20	0.31	310
July	-0.09	0.14	0.16	326
August	-0.14	0.08	0.16	300
September	-0.61	-0.10	0.62	261
October	-0.46	-0.49	0.67	224
November	-0.36	-0.49	0.61	216
December	-0.25	-0.38	0.45	213
GALVESTON				
January	-0.16	-0.45	0.48	200
February	-0.27	-0.20	0.34	233
March	-0.26	-0.21	0.33	230
April	-0.37	0.04	0.38	275
May	-0.42	0.19	0.46	295
June	-0.30	0.27	0.41	312
July	-0.13	0.25	0.28	332
August	-0.14	0.13	0.19	312
September	-0.55	-0.12	0.56	257
October	-0.37	-0.38	0.53	224
November	-0.33	-0.37	0.50	222
December	-0.24	-0.40	0.47	211

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

CORPUS CRISTI	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	-0.32	-0.66	0.73	206
February	-0.24	-0.32	0.40	216
March	-0.38	-0.27	0.47	235
April	-0.65	0.13	0.66	281
May	-0.65	0.26	0.70	292
June	-0.54	0.46	0.71	310
July	-0.32	0.42	0.53	323
August	-0.29	0.18	0.34	302
September	-0.47	-0.12	0.48	256
October	-0.41	-0.43	0.59	224
November	-0.43	-0.31	0.53	234
December	-0.14	-0.53	0.54	195
BAJA				
January	0.37	-0.45	0.58	140
February	0.55	-0.57	0.79	136
March	0.74	-0.71	1.03	134
April	0.76	-0.67	1.01	132
May	0.85	-0.76	1.14	132
June	0.73	-0.66	0.99	132
July	0.54	-0.49	0.73	132
August	0.45	-0.40	0.60	132
September	0.55	-0.54	0.77	134
October	0.52	-0.48	0.71	133
November	0.45	-0.47	0.65	136
December	0.40	-0.48	0.63	140
SAN DIEGO 200SW				
January	0.16	-0.66	0.68	167
February	0.45	-0.59	0.74	143
March	0.48	-0.74	0.89	147
April	0.69	-0.93	1.16	144
May	0.68	-1.13	1.32	149
June	0.49	-0.98	1.10	154
July	0.28	-0.83	0.88	161
August	0.18	-0.53	0.56	162
September	0.28	-0.74	0.79	159
October	0.34	-0.76	0.83	156
November	0.26	-0.46	0.53	150
December	0.30	-0.63	0.70	154

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

SAN DIEGO	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	0.28	-0.15	0.32	118
February	0.49	-0.25	0.55	117
March	0.64	-0.26	0.69	112
April	0.64	-0.21	0.68	108
May	0.67	-0.23	0.71	109
June	0.58	-0.22	0.62	111
July	0.49	-0.20	0.53	112
August	0.43	-0.15	0.46	109
September	0.54	-0.27	0.60	117
October	0.40	-0.21	0.46	118
November	0.37	-0.20	0.42	118
December	0.33	-0.19	0.38	120
SANTA ROSA				
January	0.49	-0.61	0.79	141
February	0.69	-0.91	1.15	143
March	0.98	-1.11	1.48	139
April	1.18	-1.22	1.70	136
May	1.18	-1.35	1.80	139
June	1.12	-1.29	1.70	139
July	0.88	-1.06	1.38	140
August	0.82	-1.00	1.29	141
September	0.80	-1.02	1.30	142
Ocboter	0.70	-1.06	1.27	147
November	0.55	-0.69	0.89	142
December	0.51	-0.81	0.95	148
POINT MUGU				
January	0.30	-0.21	0.37	125
February	0.43	-0.31	0.53	126
March	0.77	-0.40	0.87	117
April	0.81	-0.49	0.94	121
May	0.95	-0.60	1.13	122
June	1.01	-0.68	1.22	124
July	0.83	-0.59	1.02	125
August	0.78	-0.53	0.94	124
September	0.61	-0.31	0.69	117
October	0.50	-0.40	0.64	129
November	0.42	-0.36	0.55	131
December	0.33	-0.24	0.41	127

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

SAN FRANCISCO	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	0.32	-0.22	0.39	124
February	0.53	-0.54	0.76	135
March	0.90	-0.78	1.18	131
April	1.13	-1.17	1.62	136
May	1.45	-1.44	2.05	135
June	1.42	-1.55	2.10	137
July	1.07	-1.17	1.59	137
August	1.04	-1.12	1.53	137
September	0.84	-1.00	1.30	140
October	0.66	-0.94	1.15	145
November	0.46	-0.40	0.61	131
December	0.33	-0.37	0.50	138
POINT ARENA				
January	0.24	-0.08	0.26	108
February	0.44	-0.38	0.58	131
March	0.61	-0.48	0.77	128
April	0.95	-0.99	1.38	136
May	1.48	-1.61	2.18	137
June	1.54	-1.89	2.44	141
July	1.40	-1.60	2.13	139
August	1.23	-1.39	1.85	138
September	0.71	-1.06	1.27	146
October	0.61	-0.84	1.04	144
November	0.19	-0.14	0.23	125
December	0.26	-0.31	0.40	140
EUREKA				
January	0.25	0.06	0.26	076
February	0.28	-0.10	0.30	109
March	0.50	0.00	0.50	090
April	0.45	-1.18	1.26	159
May	0.69	-1.55	1.70	156
June	0.82	-1.99	2.15	158
July	0.73	-2.02	2.14	160
August	0.58	-1.76	1.86	162
September	0.48	-1.49	1.57	162
October	0.30	-0.75	0.81	158
November	0.04	0.02	0.05	061
December	0.21	-0.05	0.21	103

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

NORTH BEND	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	0.35	0.98	1.04	020
February	0.38	0.67	0.77	030
March	0.44	0.48	0.65	042
April	0.31	-0.41	0.51	143
May	0.35	-1.12	1.18	163
June	0.43	-1.48	1.54	164
July	0.48	-1.77	1.84	165
August	0.26	-1.16	1.19	167
September	0.14	-0.88	0.89	171
October	0.09	-0.20	0.22	156
November	0.14	0.68	0.69	012
December	0.39	1.03	1.10	021
NEWPORT				
January	0.33	1.12	1.17	017
February	0.48	0.76	0.90	032
March	0.54	0.90	1.05	031
April	0.26	-0.07	0.27	106
May	0.25	-0.56	0.61	156
June	0.31	-0.59	0.67	153
July	0.34	-0.88	0.94	159
August	0.16	-0.58	0.60	165
September	0.21	-0.39	0.45	152
October	0.24	0.41	0.48	030
November	0.06	1.09	1.09	003
December	0.29	1.59	1.62	010
ASTORIA				
January	0.13	1.01	1.01	008
February	0.35	0.49	0.60	035
March	0.27	0.50	0.57	028
April	0.37	0.24	0.44	057
May	0.46	-0.28	0.54	122
June	0.49	-0.32	0.59	123
July	0.46	-0.46	0.65	135
August	0.42	-0.31	0.52	127
September	0.24	-0.18	0.30	127
October	0.15	0.46	0.48	018
November	0.11	0.94	0.94	007
December	0.16	1.26	1.27	007

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

SEATTLE	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	-0.18	0.61	0.64	344
February	0.21	0.41	0.47	027
March	0.09	0.34	0.36	014
April	0.26	0.09	0.27	072
May	0.27	-0.02	0.27	094
June	0.50	-0.14	0.52	105
July	0.61	-0.19	0.64	107
August	0.40	-0.23	0.46	120
September	0.25	-0.08	0.26	108
October	0.07	0.33	0.33	012
November	-0.08	0.41	0.42	350
December	-0.22	0.67	0.70	342
VANCOUVER				
January	-0.17	1.02	1.03	351
February	0.05	0.73	0.73	004
March	0.31	0.63	0.71	026
April	0.56	0.41	0.70	054
May	0.36	0.10	0.37	074
June	0.46	0.07	0.46	082
July	0.59	-0.12	0.60	102
August	0.46	-0.06	0.46	097
September	0.28	0.16	0.32	061
October	0.08	0.86	0.87	005
November	0.02	1.24	1.24	001
December	-0.04	1.26	1.26	358
QUEEN CHARLOTTE				
January	-0.50	0.37	0.62	307
February	-0.27	0.57	0.63	335
March	-0.43	0.26	0.50	301
April	-0.01	0.40	0.40	359
May	-0.08	0.16	0.18	333
June	0.08	0.16	0.18	027
July	0.28	0.05	0.28	081
August	0.22	-0.01	0.22	092
September	-0.28	0.36	0.45	322
October	-0.65	0.97	1.17	326
November	-0.53	1.11	1.23	335
December	-1.03	0.87	1.35	310

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

SITKA	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	-0.99	-0.12	1.00	263
February	-0.75	0.42	0.86	299
March	-0.79	0.24	0.83	287
April	-0.41	0.31	0.52	307
May	-0.37	0.22	0.43	300
June	-0.06	0.20	0.21	342
July	-0.01	0.14	0.14	358
August	-0.06	0.30	0.30	349
September	-0.48	0.55	0.73	319
October	-0.83	0.91	1.23	318
November	-0.98	0.81	1.27	310
December	-0.80	0.16	0.82	281
CORDOVA				
January	-1.11	0.17	1.13	279
February	-0.93	0.30	0.97	288
March	-0.50	0.19	0.53	291
April	-0.37	0.21	0.42	299
May	-0.54	0.32	0.63	301
June	-0.34	0.16	0.37	296
July	-0.15	0.32	0.35	335
August	-0.01	0.27	0.27	358
September	-0.74	0.49	0.89	303
October	-0.87	0.69	1.11	309
November	-1.20	0.75	1.42	302
December	-0.92	0.33	0.98	290
SEWARD				
January	-0.46	-0.41	0.62	228
February	-0.19	0.20	0.28	317
March	-0.06	0.05	0.08	053
April	0.10	0.02	0.11	078
May	-0.17	0.01	0.17	273
June	-0.29	0.15	0.33	297
July	-0.09	0.05	0.10	300
August	0.02	0.24	0.24	004
September	-0.33	0.32	0.46	314
October	0.33	0.14	0.36	067
November	-0.09	-0.17	0.19	209
December	-0.04	-0.44	0.44	185

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

KODIAK	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	-0.12	-0.21	0.24	210
February	1.10	-0.54	1.23	116
March	0.35	-0.25	0.43	126
April	0.57	-0.19	0.60	109
May	-0.02	0.04	0.04	331
June	-0.35	0.11	0.37	288
July	0.12	0.12	0.17	044
August	0.01	0.28	0.28	003
September	-0.11	0.01	0.11	274
October	0.48	-0.32	0.58	124
November	0.09	-0.59	0.60	171
December	1.10	-0.59	1.25	118
UNIMAK				
January	0.14	-0.43	0.45	162
February	0.26	0.07	0.27	076
March	0.82	-0.29	0.87	110
April	0.81	0.22	0.84	075
May	0.26	0.11	0.28	066
June	0.02	-0.06	0.06	161
July	0.50	0.20	0.54	068
August	0.83	0.50	0.97	059
September	0.60	0.18	0.63	073
October	1.28	-0.15	1.29	097
November	1.30	0.05	1.30	088
December	0.80	-0.71	1.07	132
DUTCH HARBOR				
January	-0.01	0.03	0.03	344
February	-0.07	0.56	0.56	353
March	0.27	0.14	0.30	063
April	0.65	0.59	0.88	048
May	0.47	0.08	0.47	080
June	0.00	0.14	0.14	002
July	0.42	0.47	0.63	042
August	0.67	0.55	0.87	051
September	0.62	-0.03	0.62	093
October	1.37	-0.14	1.38	096
November	1.25	0.30	1.28	077
December	0.07	-0.03	0.08	114

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

ADAK	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	-0.48	-0.08	0.49	261
February	-0.16	0.42	0.45	339
March	0.06	0.16	0.17	022
April	0.57	0.55	0.79	046
May	0.48	0.07	0.49	082
June	-0.04	0.14	0.14	345
July	0.26	0.54	0.60	025
August	0.35	0.53	0.64	034
September	0.52	0.13	0.53	076
October	1.15	0.02	1.15	089
November	1.08	0.32	1.13	074
December	0.15	0.23	0.28	032
ATTU				
January	-0.72	-0.57	0.92	232
February	-0.69	-0.50	0.85	234
March	-0.48	-0.56	0.73	220
April	0.54	0.53	0.76	046
May	0.13	0.13	0.19	046
June	0.09	-0.01	0.09	096
July	0.13	0.39	0.41	018
August	0.33	0.41	0.52	039
September	0.35	-0.16	0.38	115
October	0.67	0.31	0.74	065
November	0.67	0.72	0.99	043
December	-0.04	0.29	0.30	352
BRISTOL BAY				
January	0.02	0.40	0.40	003
February	-0.13	-1.24	1.25	186
March	-0.08	-0.33	0.34	193
April	0.44	0.02	0.44	087
May	0.08	0.09	0.12	043
June	0.12	0.01	0.12	084
July	0.22	0.26	0.34	040
August	0.32	0.53	0.62	032
September	0.12	-0.12	0.17	135
October	0.86	-0.63	1.07	126
November	0.60	-0.14	0.62	103
December	-0.19	0.13	0.23	306

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

ST. PAUL	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	-1.39	0.05	1.39	272
February	-0.99	0.06	0.99	274
March	-0.35	-0.63	0.73	209
April	0.25	0.19	0.31	053
May	0.21	0.03	0.21	081
June	-0.02	-0.31	0.31	185
July	0.18	0.31	0.36	031
August	0.16	0.43	0.46	021
September	0.30	-0.16	0.34	118
October	1.04	-0.22	1.06	102
November	-0.03	-0.68	0.69	183
December	0.05	-0.28	0.29	170

ST. PAUL 180 WEST

January	-0.77	-1.84	2.00	203
February	-0.99	-2.02	2.24	206
March	-1.50	-1.67	2.25	222
April	0.83	0.88	1.21	043
May	0.11	-0.29	0.31	159
June	0.04	0.05	0.06	040
July	0.02	0.11	0.11	009
August	-0.60	0.57	0.83	313
September	0.10	0.74	0.75	008
October	0.42	-0.55	0.69	142
November	-0.95	-0.64	1.15	236
December	0.05	-0.69	0.70	176

NUNIVAK

January	-1.28	-0.09	1.28	266
February	-0.50	-1.81	1.88	195
March	-0.81	1.42	1.63	330
April	-0.07	0.51	0.51	352
May	-1.30	0.51	1.39	291
June	-0.03	-0.45	0.45	184
July	0.15	0.20	0.25	037
August	0.19	0.34	0.39	030
September	-0.20	0.68	0.71	343
October	0.51	-0.57	0.77	138
November				
December				

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

ST. MATTHEW	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January	-1.12	-1.43	1.82	218
February	-1.70	-0.96	1.95	241
March	1.30	0.02	1.30	089
April	-1.06	-1.07	1.51	225
May	-0.82	-1.02	1.31	219
June	0.10	-0.07	0.12	126
July	-0.05	0.35	0.35	352
August	-0.06	0.35	0.36	350
September	-0.49	0.46	0.67	313
October				
November				
December				
ST. LAWRENCE				
January				
February	-0.75	-2.19	2.32	199
March	-0.19	0.14	0.23	306
April	0.21	-0.51	0.55	158
May	-0.14	-0.45	0.47	197
June	-0.37	-0.36	0.51	226
July	-0.01	0.36	0.36	359
August	0.01	-0.12	0.12	177
September	-0.05	-0.34	0.34	189
October				
November				
December				
CAPE LISBURNE				
January				
February				
March				
April				
May	-0.78	-1.39	1.59	209
June	0.02	0.24	0.24	004
July	-0.03	0.69	0.69	358
August	0.12	0.03	0.13	075
September	-0.33	-0.32	0.46	226
October				
November				
December				

APPENDIX B CONT'd

AVERAGE MONTHLY WIND STRESS VALUES
DYNES/CM^2

BARROW	STRESS COMPONENTS X	Y	TOTAL STRESS	STRESS DIRECTION DEGREES TRUE
January				
February				
March				
April				
May				
June				
July	0.17	0.10	0.20	060
August	-0.29	-0.18	0.34	239
September	-0.53	-0.35	0.63	237
October				
November				
December				

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